DIET AND DIETETICS

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LONDON
CONSTABLE AND COMPANY LTD.

Published June 1906

Preface of the Second Edition

ALTHOUGH this Second Edition appears only a few months after the First, it has been much modified and, we think, improved. Numerous new chapters and documents have been added to complete the work : we will only indicate among the additions, the table of the food supply in Paris during the decennial period 1890–1900, the developments relating to the establishment of the coefficients of intestinal utilization of foods ; the experimental study of the requirements in energy of the man at rest or at work according to the last researches of Atwater ; the description of the mechanism of general nutrition, of the action of assimilatory and dissimilatory ferments and of the origin of vital energy. In quite another category of ideas will be found in this volume numerous details which we had not yet given on toxic foods ; the rôle of Salts in the system ; on the rules which enable us to fix the rate and the nature of alimentation according to climates, weight and height of the subjects. As to the diet of invalids, the chapters relating to arthritis, liver complaints, nervous diseases, etc., are modified and completed. I have given (p. 519) a somewhat long note setting forth the new project of alimentation for hospital patients proposed by the Medical Society of the hospital physicians and surgeons of Paris, etc. Thus this Second Edition is increased by more than 130 new pages.

In striving to correct the imperfections and omissions of the First Edition I have endeavoured to respond to the confidence of those who have hoped to find in this work the solution of a number of questions upon which public health depends and which touch upon so many medical and sociological problems.

PARIS, *May*, 1904.

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Introduction

LIFE is a perpetual function; it has for its seat the organs which, working and modifying themselves incessantly, have a constant tendency to revert to their primitive type. Thence a continual current of exchanges, the upkeep of which is borne by alimentation. According to its nature, it preserves in a normal state the composition and the texture of the organs, or rather transforms slowly their substance and, with it, the functional acts.

Nothing therefore is of greater importance than to know how to feed oneself properly; nothing is, however, more difficult or more misunderstood, and directly it is a question affecting mankind, we have to take note of tradition and sentiment with regard to one of the main conditions upon which closely depends individual health, family prosperity, the improvement of constitutions and of races. It is well known how to feed an ox, a cow, a horse or a sheep, so as to make them produce the maximum of meat, of milk, of work or of wool; one knows less well how to feed a man. Alimentation has varied with epochs, peoples and prevailing ideas; it varies much at the present day, and this grave and complex problem of the daily repair of the instruments of life, without a superfluous capital or deficit, is still determined most often empirically or according to preconceived notions; some, believing that they see the principal source of physical vigour and voluntary energy in flesh food, wish to have it in plenty, others protest that we already consume too much meat, that it charges the liver and blood with poisons and waste products and that it ought, on the contrary, to be much reduced; others extol vegetarianism and say that it suffices for all our needs and renders us less susceptible to disease. Many medical men to-day forbid alcoholic liquors, such as wine and beer, which they declare are at least useless, if not poisonous; others believe them to be stimulating and even precious nourishment. One prescribes salt and spiced dishes, another forbids them. Yesterday, we were advised to drink as little as possible while eating; to-day, it is necessary to purify the blood by an abundance of watery drinks to carry off all poisons and residues.

Nevertheless alimentation goes on: if irrationally, it leaves every day a deficit or else, on the contrary, a vexatious excess of fat, flesh, water or mineral salts, and the effects of this careless diet accumulating in the midst of the gradually modified nutritive plasmas, the cells and the organs undergo a slow degeneration,

health is enfeebled, the constitution becomes more and more affected, the tissues worn out and disease is established.

It is of the utmost importance therefore that man should learn how to feed himself rationally and to preserve his youth and his strength while there is yet time. It is also necessary that the physician should know how to prescribe for him the most efficacious diet, if he falls ill. I shall endeavour to set out in this Work the rules which respond to these fundamental needs.

It is divided into three parts :

In the *first* I unfold the general principles of normal diet for a healthy man.

In the *second* I explain the nature and application of each of the alimentary substances.

In the *third* I study the variation of diet according to individuals, races, climates, ages, in health and in sickness.

The laws of alimentary dietetics have a triple origin : *tradition* when it has withstood time and theory ; *physiological knowledge* of the normal function of the organs ; *chemical statistics* which connect the composition and daily expenditure of the organs with the composition and the balance-sheet of the foodstuffs. These three classes of considerations should support and explain each other, and alone are valuable in establishing the rules of good alimentary dietetics, those which flow simultaneously from these three sources of our knowledge and satisfy them.

I have always endeavoured to conform my conclusions to these general considerations.

The more I have thought about the subject I am treating in this work, the more I am convinced that a long empiricism has introduced little by little bad habits into our customs relating to alimentation. It appears to me that the various diatheses, which one is accustomed to attribute vaguely to delicate temperaments, to faulty constitutions and to idiosyncrasies, are most often derived from defective methods of nourishment, individual or hereditary. Arthritis, gout, megrim or neuralgic conditions, neurasthenia, dyspepsia, gastralgia, enteritis, rickets, arteriosclerosis and many affections of the skin, physical and intellectual deterioration which alcohol begets, and in an indirect way, many affections of the heart, liver and kidneys, indeed some of the forms of diabetes itself, may be attributed directly or indirectly to exaggerated or indiscreet habits of diet and can be modified or made to disappear with them.

I have thought it useful then that the numerous and delicate problems connected with the study of diet, in health or in sickness, should be examined by a biologist and a chemist, by the clear and penetrating light which our modern chemical knowledge throws on these important questions. This is the *raison d'être* of this Work.

PART I

Principles and Methods

I

DIET—ITS RÔLE—THE MECHANISM OF ASSIMILATION

ALIMENTATION has for its rôle the nourishment of the organs and the maintenance of their regular function.

Life is only carried on by virtue of the continuous changes and expenditures which create the corresponding alimentary wants. A full grown man, in good active health, uses up each day, calculated in the fresh state, about 500 grms. of his flesh or of other albuminous compounds which form his blood and his tissues. He burns a part of his fats and furnishes by their combustion, and by that of sugars and starches, which foods put at his disposal or which his organs provide him with, a quantity of energy which, calculated in heat, amounts in the adult to about 2,400 Calories in 24 hours. He loses, besides, some water every day, 1300-1350 cc. by urine, 600-700 cc. by the skin, 450 by the lungs. He exhales a quantity of carbonic acid[1] containing 610-690 grms. of oxygen and 230-260 grms. of carbon. He throws off nearly 240-270 grms. of this last element by the total amount of his excretions. He loses by his fæces or by the urine 22-23 grms. of different mineral salts, more than half formed of sea-salt. Daily nourishment should provide for all this expenditure.

Foods are therefore the solid, liquid or gaseous materials, suitable, when they are introduced into the system, for repairing the losses made by the organs and for assuring the exercise of their functions. The flesh of animals, their fat, the gluten and starch of cereals, ordinary sugar, water, salt, the oxygen of the air itself, are foods, because they have the property of maintaining our functions and preventing organic decay.

On the other hand, the flesh and eggs of certain fishes and reptiles, the albuminoid matters of some vegetables, and of many mushrooms, certain gums and the sugars which correspond to them, the salts of heavy metals, the nitrogen of the air, ozone,

[1] Claudon and Morin, *Comptes rendus*, t. CV, p. 1109.

etc., are not foods because, notwithstanding their analogy with the preceding substances, they are unsuitable for the maintenance of life or for the reconstitution of tissues.

In reality, whatever may be its composition and actual form, a principle is only alimentary if it can be placed, in traversing the digestive tube or in reaching our organs, in such a form that these can utilize it either as constructive material or as a means of action.

On this point it is expedient to give at once some explanations.

Here are some particles of yeast, yeast of beer or *mucor racemosus* of the pellicle of the grape ; sown, protected from the air, in some sweetened must, or even in a solution of cane sugar, to which is added a small quantity of phosphates of potash and ammonia, and traces of sulphate of magnesia and lime ; these little organisms are nourished, they multiply, and from their action results, with emission of heat, a production of materials of new formation, complex materials serving to construct the cells which have been formed.

In 100 grammes, calculated in the dry state, of new yeast thus formed owing to the active nutrition and the reproduction of mother cells, we find :

Nitrogenous albuminous matters . . .	38·00	grms.
Fats	2·8	,,
Cellulose matters	5·47	,,
Starchy matters and glycogen	44·00	,,
Leucin, Xanthin, Adenin, etc.	3·00	,,
Different organic acids	1·00	,,
Mineral matters	5·50	,,

From whence do all these new organic matters proceed ?

These albumins, fats, celluloses and the starchy matters did not exist in the original sweetened liquor by which the yeast is nourished and in which it is reproduced.

It must be then that these elements are fixed in the cells in the process of growth or of reproduction, not by virtue of a true intussusception, a kind of choice, owing to which the yeast would take from the liquor where it lives the prepared matters which it prefers, but rather, by reason of that mysterious aptitude, peculiar to all living organisms, which permits them to modify, to divide, to combine the substances presented to them by the nutritive plasma bathing them, in order to build up, with the products thus fashioned by them, the special materials indispensable to their proper action, and the reconstitution of their protoplasms. The particle of yeast does not choose from the nutritive centre where it lives even the substances of which it is constructed and which do not otherwise exist there : it manufactures them on the spot by means of simpler principles, which it combines to reproduce the complicated specific substances of its protoplasms. Such is the mysterious phenomenon of the nutrition of the living cell.

Let us try to analyse it, as nearly as possible, in the comparatively simple case which we have intentionally chosen.

Placed in contact with sweetened liquor, the cell of beer yeast takes possession at once of all the nitrogen of the ammoniacal salts, the sulphur of the sulphates, the phosphorus of the phosphates placed at its disposal. All these salts have nearly disappeared right from the very beginning. From the sugar already existing in the nutritive liquor, it has borrowed its carbon as well as the oxygen which is necessary to it, for it lives in surroundings deprived of air. From the mass of these elements (although we are not able in the present state of our knowledge to indicate the sequence of the intermediary processes), it has formed most complex substances : these albuminoids, phosphorated proteids, the cellulose, glycogen, etc., which we find in the cells of new formation.

The nutrition of the yeast, far from being an act of simple intussusception or of chemical deposition in the living cells of matter pre-existing in the primitive liquid as when a crystal, for example, grows in its mother water, has been then in reality an extremely complex act. The little organism has broken up the chemical substances offered to it ; it has extracted from them the radicals, or the parts which are suitable to it, and has combined them in the form of substances which the vital action had caused to disappear, and from these materials, thus formed, it has nourished itself up to the point where, having reached its highest development, it has used these food stuffs to reproduce new cells capable of recommencing the same work.

To nourish oneself, is then, in reality, to produce at the expense of the food, whatever it may be, a series of acts of dislocation, of simplification, and as a corollary and complement, of new associations, from which results the reproduction of specific constituent principles which the vital action had destroyed.

The cell of yeast adds a new act to this construction of complex and specific organic materials starting from different principles in the very simple case which we have chosen. With a little sugar and substances chemically inert, ammoniacal salts, phosphates, sulphates, etc., substances saturated with oxygen, it forms albuminous principles, fats, starch, glycogen, cellulose, etc., combustible matters filled with chemical potentiality. In order to succeed in thus changing inert material into combustible material, this organism required some source from which it could draw the energy contained in these products of new formation. Life can very well fashion matter but it can neither create it nor endow it with power. In the case under consideration, the yeast cell finds the source of energy indispensable to it in the destruction of the greater part of the alimentary sugar, transformed by it into carbonic acid and alcohol, a new system containing less chemical force than the sugar from which it comes. The difference

is partly fixed in the organic substances of new formation, partly lost in the midst of the liquid which is heated in the process of fermentation.

Sugar is then a food to the yeast cell since it permits it to act, but an indirect food which it neither assimilates nor fixes in any appreciable form in its protoplasms. It is one of the foods which furnish it with the materials for its constructions : it is also the transient means of providing the yeast with the power which it needs to create new bodies of high chemical potentiality, in particular those proteid substances suitable, by their simple hydrolytic divisions, to deliver up to the cell which will destroy them, while functioning, a part of the energy stored up beforehand in these bodies,

One sees that food is not only every matter of which the elements in being assimilated can enter into the constitution of living organs, but also every substance fit to allow them to discharge their functions, even if these substances were not at any time assimilated in nature.

If, instead of making the cell of yeast live in a solution of sugar to which had been added different salts, we had plunged it into must of sweetened grape, after having consumed *at the outset* the 0·15 to 0·30 grms. of ammoniacal salts which this must could contain per litre in the natural state, the yeast, wanting then some nitrate of ammonia, would have taken possession of that which it had found in the albuminoids and other nitrogenous substances of the juice of the grape. Placed in its natural conditions, this cell, in order to construct the protoplasms, makes use first of all of the simplest nitrogenous substances (nitrates, ammoniacal salts) ; and it is only after their disappearance that it touches the albuminoids of must which, however, much more nearly resemble in their constitution the principles which form its protoplasms. Thus the proteid substances of must, whilst being of the *same family* as those which enter into the composition of the cell of fermentation, are yet not identical with them. In order to transform the substance of those albuminous bodies with which it should nourish itself into the proteid principles suited to it, and fix them in the new tissues which it forms, the yeast is forced to a work of *assimilation* which seems more difficult and more costly to this little organism than when it makes these same specific albuminous substances out of salts, mineral sulphates and sugar. But this last aptitude is only suited to inferior organisms, and the cells of animal tissues are incapable of thus forming proteid bodies in their entirety.

It is an interesting fact (and we shall see its application to our own tissues) that yeast can exist in two ways : instead of living in the complete absence of air, it can also perform its functions in breathing and absorbing oxygen in abundance. In this new

kind of work while continuing to feed itself with sugar, it no longer transforms this element, as by the anaerobic method, into alcohol and carbonic acid, but as an animal itself does, by changing through oxidization the sugar into water and carbonic acid. This second form of utilizing its principal food, no longer by simple division of the sugar into alcohol and carbonic acid, but by total destruction, procures for the yeast cell a much larger quantity of chemical energy. Thanks to this excess of energy it can develop much more quickly in this second case; it then rapidly assimilates the surrounding matters, no longer buds forth into thin rows of daughter cells, but into branching swelling bundles, and, *for the same quantity of sugar expended*, it manufactures a weight, fifteen to twenty times greater, of new cells.

We here draw singularly near to the method of nutrition and functioning of animals. They have not, like the yeast, the capacity of living in case of need without air; but a part of the internal action of the cells of their tissues is produced anaerobically in deoxygenated and reduced surroundings. But what the animal cell could not do is to transform into nutritious substances mineral matters, such as the salts of ammonia, sulphates, phosphates, etc., fallen into chemical inaction. Like the cell of yeast living in air, animals breathe and work by virtue of the energy which they chiefly obtain from the combustion of their foods by the aerial oxygen. These foods are more complex than for the yeast cell. They should necessarily contain, besides sugars and analogous ternary bodies, albuminous elements which the animal is unfit to produce entirely.[1]

But these alimentary albuminoids are never the same as those which constitute the organs of those beings which are nourished by them; it is necessary that each kind of animal, that each of the organs of the same kind or the same individual, form the alimentary element which they may receive and identify them with the principles of which they are composed. It is necessary, in a word, that they should *assimilate* them, in the literal sense of the word, to their own substance; and that is their first work and their first expenditure.

It is not the principal one. To live is to function: in the case of warm blooded animals, it is also to supply incessantly heat and mechanical power. We shall see that, like the cell of yeast living in air, an animal can only afford this outlay of energy by means of the combustion of the oxygen of the ternary materials (sugars and fats) supplied by its food. And as its organs are used up by work, it is also necessary to perpetually renew them by the fresh capital of proteid materials which the animal has first to sink, so

[1] Exception might be made perhaps for the products of the division of the proteoses by the intestinal erepsin.

to speak, in the mould of its organism proper, before it can utilize it in the reconstruction of its protoplasms.

Such is, from a general point of view, the phenomenon of nutrition and assimilation and the sources from which the vital function borrows the energy which it expends.

The adult man in full health recuperates daily by his food what he loses by his functions. In the normal state, the two conditions balance one another, but if by an internal or external cause an inequality is produced ; if the individual happens to lose more than he gains, or to accumulate more than he loses ; if the nutrition is abnormal, such or such cells charging themselves with albumin, with fat, with nitrogenous matters incompletely used up or oxidized ; if the organs of dissimilation are choked up or exhausted ; if the eliminating filters of materials harmful to life only work imperfectly ; if food no longer provides the necessary quantities of nitrogen, iron, phosphorus, potash, lime, magnesia, etc. ; if some of the rare and specific matters, the significance of which has escaped us for a long time, iodine, bromine, arsenic, manganese, etc., diminish or disappear from the aliments and the organs ; if the oxidations are not sufficiently assured through want of the oxidizing agents ; if the other ferments of the system are too strong or too weak proportionally, or rendered inactive by pathogenic ferments of opposite action, etc., then the faulty temperament, morbid diathesis, predisposition, pathological state, acute or chronic disease are established, sometimes quickly and more often gradually. Attention to the *rules of diet* is the method of alimentation specially designed in these cases to nourish the individuals predisposed or ill, so as to co-operate with medical advice properly given, in re-establishing the organs and functions in their normal state.

How can we escape from the numerous causes of decay which we have just pointed out, and how can we normally regulate our food ? Theory, formulae, would be, *à priori*, powerless to resolve this too complex problem. We will, first of all, seek its practical solution in the examination of facts and statistics, and verify it methodically afterwards.

II

FOODS ARE BORROWED BY MAN FROM THE THREE KINGDOMS —TYPE OF AVERAGE ALIMENTATION

IN all countries and at all times, man has obtained from the three kingdoms—vegetable, animal and mineral—the nourishment which is indispensable to him. Without doubt, in extreme climates, the Laplander or Greenlander feeds himself almost entirely on the flesh and fat of the fish or cetacea which he catches, the negro on the roots and fruits of his forests; but neither one or the other seeks with less avidity the little vegetable or animal food which the scanty herbage of the polar regions furnishes them with, and the game or the rare domestic animals which can live in the Torrid Zone. The civilized man of our country, rich or poor, forms his nourishment of meat, milk, bread, fruits, water, and of different salts which his foods bring him, or which he adds to them.

In thus varying his food, and borrowing it at once from animals, plants, and minerals, he obeys, as we shall see, an instinct which guides him more surely than his reason.

Of all material mechanisms, living or not, that of the animal is the most complex: there enters normally into his constitution seventeen or eighteen simple bodies: hydrogen, oxygen, sulphur, fluorine, chlorine, bromine, iodine, nitrogen, phosphorus, arsenic, carbon, silicon, potassium, sodium, calcium, magnesium, iron and perhaps copper, manganese, aluminium, boron and vanadium. All these elements (and perhaps those which we do not yet recognize), associated in a very complex manner, are like the special pieces, the wheels or constituent parts of complex principles without which the life of certain organs, and the general life of the individual, remain unrealizable. It appears then very improbable, if not impossible, that a single alimentary substance, be it milk, flesh or bread, and even that a single kingdom exclusively, either of animals or plants, could furnish all the elements at once, at least in relative acceptable quantities and in a sufficient weight.

Carnivorous animals, it is true, can feed themselves indefinitely on meat and do without vegetables by reason of the aptitude they have of transforming into ammonia a notable quantity of

their nitrogenous aliments and of thus alkalizing their blood. But man only possesses this faculty to a relative extent.

The herbivorous man or the vegetarian can certainly live solely on herbs or vegetables, but it is only by accumulating a mass of nourishment so that a considerable portion of it remains unused. It is rejected after having furnished the necessary principles, owing to the superabundance of some and to the inutilization of others.

Having neither the aptitude of the carnivora, nor the digestive capacities of the herbivora, man at all times and among all peoples has had recourse, in order to nourish himself, to a mixed diet at once vegetable, animal and mineral. The most natural food for our species after milk, bread, even when water and salt have been added to it, does not indefinitely suffice, as the experience of the Englishman Stark, who was the victim of it, has demonstrated.

In a general way, we observe that our organs have above all, while destroying themselves by the very discharge of their functions, the need of drawing from nourishment the materials of which they are constructed, or those which resemble them the most by their constitution.

In the normal state these organs are composed of cells formed of a membrane filled with an albuminous, very complex protoplasm, enveloping a nucleus very rich in phosphorus.

The albuminous substances which, combined with water and some salts, compose in a young animal almost the whole weight of their tissues, form the great family of *albuminoid or proteid* matters, the most complicated elements of the animal or vegetable economy. They are called *albuminoids* because they have the general properties of the principal material of the white of egg or *albumen*. All the albuminoid or proteid principles of the young cell and of its nucleus contain carbon, associated with hydrogen, oxygen, nitrogen, sulphur, phosphorus, more rarely iodine or iron. These protoplasmic albuminoids are most often amorphous, incapable of dialysis, of an inmost asymmetric texture, for they all act on polarized light. Chemically indifferent, they can play at the same time the part of bases or of very feeble acids. They are all capable of hydrolysis (that is to say, of dividing while taking up water) under the influence of acids diluted with water, of bases, of acids, ferments, etc. Owing to this first step of hydration, after having given a series of phosphorated derivatives, the *nucleins,* and different intermediary bodies, they are transformed definitely into a series of complex amides, leucin, tyrosin, oxamide, aurin, glycocoll, urea, etc., which we find again in most of our humours and tissues.

By the side of these fundamental proteid substances which compose the essential part of our cells, substances at once nitro-

genized, sulphurated and phosphorated (*cytoproteids and nucleoproteids*), there are generally to be found more simple albuminoids like these, but deprived of phosphorus. The albumen of egg is the prototype of them. They appear to arise from the preceding by divisions or to proceed from alimentary substances. With these we always find in the animal cells, fats resulting from the union of fatty acids with a common alcohol, glycerin, carbo-hydrates, like starch and sugar, glycogen $(C^6H^{10}O^5)^n$, glucose $(C^6H^{12}O^6)$, inosit or muscular sugar $(C^4H^{12}O^6)$, etc.

The albuminoid substances, phosphorated or not, are not free in the cell; they are united with water and different salts, principally with phosphates of potash, magnesia and lime. The cellular elements of each tissue bathe, so to speak, in an interstitial humour or plasma of lymphatic or sanguineous origin, which receives the products resulting from the discharge of the functions of organs (ferments or materials destined to nourish other tissues or to be excreted) and which brings at the same time to each cell the nutritive principles of alimentary origin. Of these last principles some, the smallest number, are stored up just as they existed in the aliments, some must be modified in their composition and structure before being utilized, as I have already shown (pp. 2–4).

It is important then, for the best economy of the forces of which the living being disposes, that alimentation should furnish it with those nutritive substances in a form nearest to that which will permit of their final assimilation. Hence, without doubt, the advantage of that varied alimentation which a long experience guided by instinct has caused us to adopt.

The necessity of providing each organ with a number of specific materials, varying according to the tissue, explains the folly of attempts made to artificially feed animals with mixtures, apparently reasonable, of alimentary elements too much simplified, or even entirely with natural foods, such as meats or bread, taken exclusively.

It is necessary therefore to guard oneself against all theoretical feeding, even if apparently perfectly rational, and in order to feed normally, it is before all necessary to examine how comfortable and prosperous populations feed themselves, to determine the abuses which a long usage has been able to introduce gradually into general habits, abuses of which the criterion is a physical degeneracy and weakness of the powers of the mind or of the will. We shall establish later on that it is indeed more exact and more sure (if not apparently more scientific) to take as a type of normal alimentation that of populations living in a temperate climate and under average conditions of health and of mechanical work, than to base the rules of diet upon the study of some particular individual cases which may falsify the results.

Average Annual Consumption of an Inhabitant of Paris ; Decennial Period 1890 to 1899. According to the *Renseignements statistiques sur les services municipaux de l'approvisionnement de Paris* (Préfecture de la Seine).[1] (The population has varied from 2,344,530 to 2,536,834 inhabitants, not including about a fifteenth of foreigners).

Years.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.[2]	Average per head per year.
Bread	kg. 146	kg. 146	kg. 146·400	kg. 146	kg. 146	kg. 146	kg. 146·400	—	—	—	—	kg. 146·100
Pastry, pies, cakes	—	—	—	—	—	—	—	—	—	—	—	7·400
Butcher's meat	64·876	63·624	64·586	65·410	60·719	61·027	62·298	kg. 62·497	kg. 65·564	kg. 66·856	kg. 72 902	kg. 64·020
Pork, salted meats, cooked meats	10·745	10·249	10·542	10·441	9·710	9·811	11·555	12·026	11·823	11·871	12·891	10·850
Poultry and game	11·472	10·595	11·239	11·288	10·285	11·495	12·242	11·540	10·703	11·723	12·559	11·290·
Fish	13·096	13·744	10·206	10·400	11·076	11·086	11·199	10·712	15·583	15·153	15·833	12·220·
Eggs (in kilogrammes)	9·520	9·499	9·572	9·620	10·000	10·045	10·118	10·457	10·609	10·737	12·114	10·010·
Dry cheeses	2·275	2·237	2·645	2·523	2·432	2·765	2·660	2·771	2·750	2·918	3·276	2·610
Fresh herbaceous vegetables	—	—	—	—	—	—	—	—	—	—	—	—
Vegetables (in grain)	—	—	—	—	—	—	—	—	—	—	—	—
Potatoes	—	—	—	—	—	—	—	—	—	—	—	—
Rice and other feculents	—	—	—	—	—	—	—	—	—	—	—	—
Sugar	—	—	—	—	—	—	—	—	—	—	—	—
Butter and oil[3]	8·501	8·164	8·029	8·075	8·031	8·375	8·316	8·688	8·539	8·710	8·986	8·35
Milk	—	—	—	lit. 66·12	lit. 67·50	lit. 67·50	lit. 73·30	lit. 79·90	lit. 88·00	lit. 95·90	lit. 103·1	lit. 77·86
Wine	lit. 178·62	lit. 183·940	183·770	186·00	194·00	200·00	190·73	193·69	177·17	205·00	204·42	189·32
Cider, perry, hydromel	3·04	4·52	—	—	9·28	6·26	6·90	3·16	1·94	3 70	6·75	3·88
Beer	11·67	11·49	—	11·90	10·52	11·90	10·35	9·51	9·47	10·46	13·96	10·82
Brandy	6·40	7·23	8·20	6·68	7·18	7·22	7·19	7·16	8·07	6·00	8·06	7·12
Salt	kg. 7·301	kg. 7·067	kg. 7·179	kg. 7·100	kg. 7·291	kg. 7·267	kg. 7·237	kg. 7·586	kg. 7·037	kg. 7·557	kg. 8·175	kg. 7·27

1 In this table are not included foods not subject to the octroi such as : Biscuits, cocoa, jams, preserved fruits, fresh or dry fruits, green vegetables, dry vegetables, nourishing pastries, potatoes, sugar, lard, salted meats, tea, coffee, chocolate. We will give a further statement, in our final average, relying on facts taken from other sources and on our personal statistics established for several Parisian families.

2 We have given here the results of the year 1900, but we have not included the numbers of this exceptional year (*Exposition universelle*) in the average decimal calculation in the following column of average.

3 Not including lard.

One cannot be too much on one's guard against the variations or exceptions which result from temperaments, from customs of races, from arbitrary choice made by the most conscientious investigators. Uncertainty increases in proportion to the small number of subjects which one thus studies, and the complicated analysis of so delicate a problem as the establishment of the alimentary balance increases it still further.

Average alimentation of Paris—From this point of view I have thought that nothing would afford better demonstration than a detailed examination of the ordinary feeding of the whole of the inhabitants of a large community like Paris. The 2,800,000 individuals (Parisians or foreigners) included within its walls receive annually an enormous quantity of most varied foods, an amount which I have verified by the entries of the municipal registers, complemented by the statistics of the weights of fresh and dry vegetables not inscribed in the books of the town, but which I have determined according to the consumption of a certain number of average families. It has thus been possible for me to establish not only the average quantity of food consumed in Paris, but the consumption that is made of each of the principal alimentary commodities.[1]

Here is the result of this inquiry for the last decennial period 1890–1899.[2] (See table preceding page.)

From these figures, the totals for the dry or green vegetables, and potatoes, pastries, lard, sugars, sweetened preserves, etc., and thanks to the facts which I myself have remarked concerning a certain number of average families, it is ascertained that the daily consumption of an inhabitant of Paris in the last decennial period has been as follows[3]:

[1] I have made, for the first time, a detailed study of the food of Paris at the request of the Minister of War, in view of the rules to be followed and the provisioning to be determined, to insure in time of war the defence of the intrenched camps. I have taken as my basis the consumption of Paris. I have intentionally mixed the adult men, women and children, considering that the work of the one almost compensated the lesser weight of the others, the average of this feeding would approximately represent the quantity of food utilized by the average male adult *living quietly*. Returning to this calculation and trying to keep an account of the number and relative weights of the women and children, my colleague and friend, M. Ch. Richet, has arrived at a number a little greater than mine, but which I believe, not without reason, is too great because he has not sufficiently taken into account the fluctuating foreign population, nor the excess of consumption due to the working classes.

[2] I have made this inquiry for the preceding decennial period 1880–1889 and I have given the result in the First Edition of this work (p. 12). (See Note 4 on next page.)

[3] Obtained by dividing the annual average consumption resulting from the general table above (1890–1900) by the number of days in the year.

Average Food per Day of an Inhabitant of Paris (1890–1899).

Bread	400 grms.	Bread and cakes 420 grms.	
Pastry and cakes	20 ,,		
Butcher's meat [1] (beef, veal, mutton, horse)	175·3	Gross total with bones and feathers 269·7	Net weight in boned meat 216 grms.
Pork, salted meats, cooked meats	30·0		
Poultry, game	31·0		
Fish	33·4		
Eggs (weighed with shell)	27·4 klgrm.	net	24·1 grms.
Cheese (dry or cream)	8·1 ,,	,,	8·1 ,,
Butter, oil, etc.	28 ,,	,,	28[2] ,,
Fresh fruits	70 ,,	,,	70 ,,
Green vegetables	250 ,,	,,	250 ,,
Dried vegetables	40 ,,	,,	40 ,,
Potatoes, rice	100 ,,	,,	100 ,,
Sugar	40 ,,	,,	40 ,,
Milk	213 cc.	,,	213 cc.
Wine	518·6 cc.	Total: 557·6 cc or 532 cc. to 9°	532 cc.[3]
Cider, perry, hydromel	10·6 cc.		
Beer	29.0 cc.		
Brandy, liqueurs, etc.	19·2 cc.	In pure alcohol	9·5 cc.
Kitchen salt	20 grms.		20 grms.
	2,078 grms.		

One will notice how constant the alimentary consumption of an inhabitant of Paris remains in comparing the average for 1890–1900 with the average for the preceding years 1880–89 which I give here in a note.[4]

The consumption of bread and meat has remained practically the same. Thanks to the advice of medical men and to the practice of sterilization, that of milk has very sensibly augmented: from 150 cc. per head per day it has risen to 213 cc. It is only by reason of a verification of averages, which I consider most

[1] Bones are included and count as a 50th part.

[2] Including fat and lard.

[3] All alcoholic liquors are here reduced or calculated to 9 per cent.

[4] In our *First Edition* we have given as the average consumption per day of an inhabitant of Paris (*Previous period* 1880–1889) the following numbers —

Bread, pastry, cakes	430 grms.
Meat, game, fish, fowl, offal (raw)	266 ,,
Milk	150 ,,
Eggs	30 ,,
Fresh fruits	90 ,,
Herbaceous vegetables	200 ,,
Dried vegetables	40 ,,
Potatoes, rice, other thick foods	100 ,,
Cheese	12 ,,
Sugar	40 ,,
Butter and oil	28 ,,
Wine, beer, etc. (brandy calculated at 10 per cent.)	650 ,,
Total weight	2,036 grms.

exact, that I have carried the consumption of herbaceous vegetables from 200 to 250 grms. per day. The use of wine appears to have somewhat diminished in the last decennial period. It has, however, risen again during the last years. On the other hand, alcoholic liquors have advanced from 4 to 7 litres per head per year.

Let us notice that these numbers relating to an average inhabitant of Paris include children and women. The quantities per head per day of bread, meat, vegetables and wine would be a little higher if they were calculated for adults alone. But it seems that one may consider that the smaller alimentation of the woman and child, who weigh less and do not work, almost balances that of the adult workmen who work and eat more than the child and the bourgeois at ease. We will consider that the deficit of some compensates the excess of consumption of others, and that the alimentation thus calculated agrees very nearly with the maintenance of the average man of our climate living in a state of repose.

We shall show, moreover, later on, that our figures correspond very exactly to the measure of the needs of the adult who does not furnish mechanical work, needs calculated according to other methods, in particular according to the nature and quantity of his total excretions, or according to the expenditure in energy of the average man, and we shall deduce our conclusions from these facts.

For the moment we will confine ourselves to the statement, according to the tables given above, that at Paris the food consumed (drinking water not included) weighs about 2 klgrms. for 24 hours and that in this average quantity of food, for 100 parts of foods (nourishing drinks, cider, beer and alcohol not included) one finds :

Foods of animal origin	22·8
Foods of vegetable origin	77·2

Of the 22·8 per cent. of animal matter, meat and its congeners form 19·3 per cent. ; milk and eggs 3·5 per cent.

In the 77 per cent. of vegetable origin, bread and its analogues account for 30 per cent., dry vegetables, potatoes and fecula, sugar, for 13 ; fresh vegetables and fruit for 22 to 23 per cent.

Nourishing alcoholic drinks form about a quarter, or 25 per cent. of the total ration.

Let us add that in the daily food fresh vegetables are represented for about a fifth part by cabbages, a fifth by carrots, turnips, radishes, etc. ; the rest include sorrel, spinach, various salads, onions, celery, asparagus, mushrooms, peas, haricot beans, etc.

One sees all the detailed information which the study of the

feeding of this great human society provides us with and also how many varieties of foods and different elements, borrowed from the soil which nourishes the plant, are furnished by a vegetable diet.

Finally let us add to our daily dishes about 8 to 9 grms. of salt.

That is not all. Foods introduce into our organs a quantity of water insufficient to compensate for our losses ; whence the sensation of thirst. The water which the preceding estimate gives is calculated in the following table :

Per Day.	Quantities of Fresh Food.	Quantities of Dry Food.	Corresponding Water.
Meat, milk, eggs, cheese . .	492 grms.	123 grms.	369 grms.
Bread and its congeners . .	490 ,,	319 ,,	171 ,,
Fruit, vegetables, potatoes, etc.	480 ,,	59 ,,	421 ;,
Wine, cider or beer (calculated at 9% for the wine)	557 ,,	62 ,,	495 ,,
Total water derived from the food, about . .			1456 grms.

Excreting daily by the kidneys, the skin and the lungs about 2,450 grms. of water, the adult will then have need of the difference (2,450 – 1,456) or very nearly 994 cc., about a litre, of water for his daily drink.

Such is the balance-sheet of the normal alimentary allowance of an average population where the number of those who live sparingly, and scarcely consume what is necessary, nearly make up for the superfluity of those who allow themselves *luxurious nourishment* ; an active, intelligent population of workmen, of townsmen, of women and children, where the work of some, without being exaggerated, counterbalances the ease of the others ; an immense agglomeration, living in a temperate climate, having a relatively large contingent of strangers from all parts of our country and of the civilized world[1] ; representing, in a word, a good mean as the type of feeding of modern people, energetic and laborious. We shall, in consequence, consider the preceding figures as a provisional but sufficient basis for discussion, *established apart from any prepossession or theoretical consideration*, except to verify afterwards these numbers by comparing them with the results given by other methods.

I shall show later on that these data, deduced in a purely empirical manner, respond very exactly to the most precise teachings of the laboratory and to the best studied theoretical needs.

Without doubt, even in our climate and in our country, on the coast of Brittany, in Limousin, the Auvergne, on the shores of the Mediterranean, there are peoples, who altogether producing a sufficient quantity of labour, are content with a very inferior

[1] About the fifteenth part of the total population.

daily ration to that of Paris. Buckwheat bread, some butter, and, in times of plenty, some little fish and pork, suffice daily for a poor family of Breton fishers. Our peasants of the south, the hard workers which Spanish Catalonia especially and Piedmont send us, are satisfied with bread, salt, oil, garlic and with meat once or twice a week. Some handfuls of rice or dates suffice for the Hindoo and Arab on which to pass the day without suffering from hunger. But from individuals or populations so badly nourished, one must not expect great intellectual activity, laborious and continued work or energy indefinitely sustained, nor above all a resistance to the causes of decline which result in a premature old age. Upon the whole, whilst doing a sufficient amount of work, even excessive at times, these poor people, insufficiently fed, finish by languishing into a kind of passiveness and dreaminess and are exhausted more or less quickly. With this insufficient diet man is quickly worn out and dies earlier, whereas the better nourished workman of our large towns, in spite of the often vicious habits which the immoderation of civilization brings and permits, has generally before him several years longer to live.

Thus, as we have already remarked, the alimentary régime such as one deduces from the observation of the great labouring and prosperous human agglomerations, is a *mixed* régime and not exclusively vegetarian. In Paris, for 100 parts of food, including alimentary liquors, 23 are borrowed from the animal and 77 from the vegetable kingdom. We shall see later that the property of these mixed régimes is to carry to its maximum the utilization of alimentary materials. Thanks to the association of vegetable and animal nourishment, about 92 per cent. of albuminoid substances, 95 per cent. of fats, 97 per cent. of sugars and starches are digested in the intestine and then utilized ; so that with a diet purely animal or vegetable the utilization of the albuminoids may fall to 85 per cent. and less, and that of the fats to 70 per cent- New proof that, if one places oneself in normal conditions, the facts deduced from observation form the most solid bases of our theories. The criterion of the exactitude of these latter will always be that they fit the most general facts of observation.

We shall try further on to determine exactly the alimentary needs of diverse populations varying with the climate, manner of living, customs, age, race, work furnished by the workman, etc.

III

NORMAL PROPORTIONS OF THE ORGANIC FUNDAMENTAL PRINCIPLES OF ORDINARY ALIMENTATION—METHODS OF EXPERIMENTAL STUDY OF THE NUTRITIVE BALANCE-SHEET

THUS, as we have said, the tissues of animals are composed essentially of water and of albuminoid or phosphorized proteid matters combined with some salts. The tissues and plasmas contain, in a fresh state, the following percentage quantities of these albuminous materials, calculated here in the dry state, for some of our most important organs.

	Albuminoids.	Water.
Muscles	20·7	72·0
Total blood	20·3	78·9
Red blood corpuscles	20·6	63·0
Blood plasma	8·3	89·8
Lymph	3·4	95
Liver	12·9	73·0
Brain, etc.	11·6	77·0

Fats and some carbo-hydrates of the nature of sugars and starch, bodies directly supplied by alimentation or, in some part, derived from the first step of division of the protoplasmic albuminoids, generally accompany these latter substances in the cell in varying proportions, or accumulate in some of the tissues. At the same time one finds, as a result of vital action, the products of the continual destruction of the protoplasms: urea, different amides, complex nitrogenous extractive bodies, chlorides, sulphates and phosphates, carbonic acid, etc., so many waste products carried away by the circulation and destined to be rejected by the kidney, the skin, the lung or the intestine.

In what measure and relative proportions the albuminous elements suitable to the reconstruction of the protoplasms, on the one part, and on the other the ternary bodies in reserve, the sugars and fats which constitute the principal source of the energy of which the animal disposes, in what proportion ought these different

elements to be provided for us by the daily food ? It is theoretically impossible to calculate it, except with great uncertainty, for, as we shall show, we need not the precise necessary amount corresponding to the losses of the economy during the digestion of food stuffs, but a superfluity in order to evenly repair the wear and tear of the protoplasms and to provide for the expenditure of nitrogenous substances. The reserves or deficits of nitrogenous and ternary bodies already assimilated or lost, greatly influence also the proportions under which these different substances ought to be found mixed in the food. It is then a very delicate problem, beyond the authenticated statistics made on a great human community, to try to determine logically, by experimental study of a few individuals, the daily necessary proportion of each of the fundamental sources of normal alimentation. I have tried, however, to resolve this problem by various methods which I will now explain.

A. *Empirical methods.* It seems logical to try to resolve this question by the strict observation of facts, whether one takes as an example a small number of individuals functioning and nourishing themselves freely, and in well defined conditions of age, weight, constitution, etc., and that one should generalize from these observations : or whether we start with an examination of the alimentation of a great human community living under normal conditions, and calculate the assessment of the albuminoid and ternary elements existing in the average usual ration thus determined, reserving the right afterwards of comparing or controlling the empiric results obtained with those which are brought about by the study of the alimentation of *typical subjects.* This is the average empirical method which I have believed it preferable to have recourse to, for the reasons already shown (p. 10). Knowing the number of the inhabitants and, even in its details, the quantity and the *nature* of the foods consumed by the immense community of Paris during a period of ten years, and referring to the tables of the average composition of the foods which I shall give further on (Chapter XII), it has been easy for me to calculate per day and per head, the quantity of each of the nutritive fundamental principles (albuminoid bodies, fats, carbohydrates, salts) contained in the average daily ration thus determined. I have made this calculation for the whole of Paris and for the 3,652 days of the decennial period 1889-1899. Here are the results obtained, for twenty-four hours, for the average individual :

TABLE OF THE AVERAGE ALIMENTATION OF AN INHABITANT OF PARIS (Decennial period 1890–1899).

Matter and Weight of Food consumed per head and per day.	Gross Weight.	Net weight (exempt from waste, bones and feathers).	Alimentary Fundamental Group.		
			Albumins.	Fats.	Carbo-hydrates
			grms.	grms.	grms.
Bread	400 grms.	420 grms.	30·20	1·95	201·0
Pies, cakes, pastry	20 ,,				
Butcher's meat	175·3 ,,				
Pork, salted meats, cooked meats	30·0 ,,	216 net ,,	43·76	15·88	6·50
Poultry, game	31·0 ,,				
Fish	33·4 ,,				
Eggs (with shell)	27·4 ,,	24·2 ,,	3·10	3·00	0·10
Cheese	8·1 ,,	8·1 ,,	7·09	2·53	0·13
Butter, oil, etc.	28·0 ,,	28·0 ,,	0·25	24·0	0·00
Fresh fruits	70·0 ,,	70 ,,	0·15	—	5·00
Herbaceous vegetables (peeled)	250 ,,	250 ,,	4·55	0·50	11·25
Dried vegetables	40 ,,	40 ,,	9·44	0·80	22·24
Potatoes, rice	100 ,,	100 ,,	1·30	0·15	20·00
Sugar	40 ,,	40 ,,	—	—	38·40
Milk	213 cc.	213 ,,	7·79	7·73	9·48
Wine	518 ,,				
Cider, perry, etc.	10·6 ,,	532 cc.[1]	—	—	69[1]
Beer	29·0 ,,				
Brandy, liqueurs	19·2 ,,	9·5 cc.[2]	—	—	17·2
Salt	20·2 grms.	20 grms.	—	—	—
Total weight of daily ration	2078·0 grms.		102·1	56·54	400·40[3]

Such is in quantities, nature and proportions, the average daily ration for the maintenance of an inhabitant of Paris.

In passing I may observe, in order that I may later draw conclusions from the fact, that of the 102 grms. of albuminoids 56·6 grms., or more than half, are of animal origin.

C. Voit had already observed that whilst the animal albumin consumed by a member of the middle class in easy circumstances amounts to 77 per cent., the vegetable to 33 per cent. only; with the workman meat furnishes 37 per cent. only of the total of the proteid substances. Uffelmann in the food of four vigorous artisans finds 46 per cent. of albumin in the meat and 54 in the vegetables of their diet. These are almost the proportions yielded by the whole population of Paris.

We think, like Uffelmann, that there is a danger of sensibly

[1] Calculated in alcoholic liquors brought up to 9°. The alcohol has been afterwards transformed and reckoned in corresponding glucose.

[2] Calculated in pure alcohol and corresponding sugar.

[3] This weight of 400·4 grms. reduces itself to 314 grms. carbo-hydrate on an average, if one does not add, as one has done here, the sugar corresponding to the alcohol of the fermented liquors consumed per day.

exceeding these proportions and of asking muscular flesh for more than 60 to 65 per cent. of alimentary nitrogen.

From this instructive table of Parisian alimentation we still maintain that, conforming to what is admitted by the most competent hygienists, the relation of the proteid substances to the ternary bodies (fats and starches) is 1 to 4·5 or 22 of the first for 100 of the second. We shall see that it is not desirable that the weights of the proteid matters should exceed one quarter that of the ternary substances.

To the very detailed and precise quantitative statements which this table furnishes, doubtless it will be objected that the Parisian dietary, although calculated for a great number of individuals at once and for a period of ten years, cannot exactly represent the *average alimentary maintenance of individual adults living at ease* ; that it is not certain that the labour of some may be exactly balanced by the repose of others, or by their more feeble weights ; that man eating more than woman, the balance on this point is still doubtful. These objections may appear valid, but they entirely disappear if one compares the figures thus arrived at with those obtained from other very different methods which I shall now explain.

B. *Method of free alimentation of a few individuals taken as types.* The method followed by Forster[1], Hock, C. Voit, Smolensky, etc., to determine the ration of maintenance and its average composition, consists in studying the ordinary daily feeding of a few individuals specially chosen as types, living in relatively simple conditions, in a state of perfect health and not varying, or very little, in weight ; to give an account of the quantity and the nature of the foods which they consume in order to remain in this state of equilibrium and health, then to deduct from these observations, made under conditions as well defined as possible, the quantities of each of the necessary alimentary principles for the maintenance of health, and eventually to generalize the observations thus made. To this method I shall raise, as an objection, the influences that every individual introduces into his food, willingly or not. To counterbalance the chances or the possible caprice of these personal régimes, it would be necessary that an observation should be made of a great number of people at the same time and for a considerable period. In a word, the study of alimentation confined to the observation of a too small number of persons with whom the weights, the state of actual health, that of the reserves or deficits, origin, habits, age, suggestion or preoccupation, of experience, etc., can do much to vary the needs, all these causes expose one to errors of appreciation which one would only be able to get rid of by means resulting from very numerous trials,

[1] Zeitsch f. Biolog., Bd. IX, p. 381.

even if the chosen individuals responded well to the average type, a condition always very difficult to establish.

Be that as it may, from the point of view of the fundamental alimentary principles of the daily ration of maintenance, the numbers which have been obtained by this method are as follows :

Nutritive Principles Contained in the Régime of Maintenance of a few Average Individuals or Groups of Individuals submitted to a Generous Diet.

Subjects.	Nutritive Principles.			Authors.
	Albumin.	Fats.	Carbo-hydrates.	
	grms.	grms.	grms.	
Young doctor	127	89	362	Forster
,, ,, ...	134	102	292	,,
Man of 25 years	116	68	345	,,
English citizen	130	95	325	,,
English workman (work very moderate)	132	90	450	,,
English workman (not occupied)	90	80	285	,,
German workman (70 kgrms.) (at rest)	137	72	352	C. Voit
Doctor (48 years)	92	61	235	Beaunis
English doctor (25 years) . . .	108	77	378	Hock
A workman of the South of France at rest, 29 years, 67 kg. (wine not included)	85	50	378	A. Gautier
Lawyers, professors, savants of the United States (11 observations)	112	80	305	Atwater
Men and women sedentary or working very moderately	100	—	—	,,
Two poor workmen's families at Pittsburg	80	95	308	Atwater Beneke
Doctors, Professors, lawyers (German) average	110	102	269	Ranke
Swedish doctor weighing 60·7 kgrms.	99·5	103	299	Siven
Danish doctor (37 years) 73·5 kgrms.	135	140	250	Juergensen
Doctor weighing 62·5 kgrms. (German)	90	79	285	Beneke
Russian family diet	100	44·3	470	Smolensky
Students of Padua, easy circumstances	104	50·4	351	Serafini and Zagato
Average	110	80·9	317·1	

If, as in our calculation of the average consumption of Paris, we add to these numbers the alcohol (not estimated by the preceding authors), which I have placed at about 40 grms. per day in whatever form it may be, which corresponds to about 80 grms. of glucose, the average number of 317·6 grms. of carbohydrates obtained becomes 397·6 grms.

In spite of the great errors in the numbers furnished by this method (errors which are enough to prove its insufficiency), we see that the average to which it leads for the weights and proportions of the albuminous principles, fats and carbo-hydrates of the daily ration of maintenance of the adult at rest, differs very little from ours.

C. *Method of study of normal alimentation founded on the preservation of nutritive equilibrium.* A third method, certainly the most rational in appearance, consists in feeding a certain number of average healthy individuals in such a fashion that what they lose in nitrogen and carbon from their total dejections may be almost equivalent to their alimentary gains. If under these conditions the state of health and the weight of the body remain almost constant, and if in the period considered, the weights of the carbon and nitrogen lost and gained are approximately balanced, we can admit that the composition of the subject experimented upon has remained the same and that the needs of his organism have been exactly represented by the alimentary deposits made at the same time with a small correction which we will now explain. In these conditions we are able to substitute for one individual principle of the ration under observation others of known weights and find out if they are equivalent, the equivalence being demonstrated by the maintenance of equilibrium, the weight of the subject and also by a like production of caloric or mechanical energy in the two cases.

Concerning the measure of the elements of calculation of this nutritive balance, detailed explanations will be given later (see Chap. VII). For the moment we will only reason according to numerical results.

Take for instance a subject who, after some trials and modifications in his alimentary ration, has lost by the total of his excretions, during a period of three to four days, nearly the same quantity of nitrogen and carbon as that which he absorbs by this food. Let us suppose that the calculation has given us for one day :

		Nitrogen.	Carbon.
Losses in 24 hours	By urine	17·5 grms.	9·5 grms.
	By the excretions	1·5 ,,	5·0 ,,
	By respiration, perspiration	0·0 ,,	260·4 ,,
	Total	19·0 grms.	274·9 grms.
		Nitrogen.	Carbon
Gain in 24 hours	112·5 grms. of albumin	18 grms.	61·5 grms
	54 ,, of fats	0·0 ,,	41·3 ,,
	324 ,, of carbo-hydrates	0·0 ,,	154·0 ,,
	Total	18 grms.	256·8 grms.

The subject under observation has then lost in twenty-four hours :

Nitrogen = 19 grms.—18 grms. = 1 grm., and
Carbon = 274·9 grms.—256·8 grms. = 18·1 grms.

The nitrogen having been borrowed from decompositions of the albuminoid substances, these latter containing 16 per cent., the excess of 1 grm. of nitrogen lost besides that of the foods, corresponds then to 6·25 grms. of albumin consumed per day at the expense of the tissues of the subject under observation. But these 6·25 grms. of lost albumin correspond, as we know, to 3·36 grms. of carbon,[1] it follows that of the 18·1 grms. of carbon lost by the subject in the course of twenty-four hours, 3·36 grms. may be attributed to the destruction of his own proteid substances and that 18·1—3·36 = 14·65 grms. are derived from his fats, for these are the only principles not nitrogenous capable of destroying themselves and which animals are rich in. But according to the average composition of fatty bodies (766·5 per cent. of carbon), these 14·65 grms. of carbon correspond to 19·12 grms. of fat.[2]

It follows from this calculation that the individual experimented upon has consumed in the twenty-four hours considered :

	Brought by Foods.	Borrowed from the Body.	Total.
Albuminoids .	112·5 grms.	6·25 grms.	118·75 grms.
Fats	54·0 „	19·12 „	73·12 „
Carbo-hydrates .	324 „	—	324 „

The ration of maintenance then, for the subject under experiment, has been, *not* albuminoids 112·5 grms. ; fats 54 ; carbo-hydrates 324, *but* albuminoids 118·75 grms. ; fats 73·1 grm. ; carbo-hydrates 324 grms.

If, instead of losing substance, the subject was, on the contrary, enriched by nitrogen and carbon, one would deduct proportionally from the apparent ration the quantities of albuminoids and fats stored up, in this second case, by the tissues.

This method of determining the nutritive balance-sheet has its advantages and its inconveniences. The advantages are that, on the same subject, one can measure exactly the quantities of foods utilized and the weights of proteid or fatty substances accumulated or consumed in the tissues. One can study the replacement of one substance by another, of meat for example by gelatine, fat or starch, of ternary bodies by alcohol. We can also by this method take account of the effects of substances termed "economizing," such as coffee, tea, kola, and aromatic matters. But this method also has its defects, which are chiefly technical. Its complication is such that one can only make the many determinations of which it permits by means of delicate and costly apparatus (respiratory bells of Regnault and Reiset, apparatus of Reiset, Pettenkoffer and Voit ; and Atwater's Respiratory Cal-

[1] Albumin contains 52·1 grms. per cent. of carbon.

[2] The weight of carbon multiplied by 1,307 gives the weight of the fat.

orimeter, see Chap. VII). The method forces one also (and this is the principal cause of its indefiniteness) to limit oneself to the study of a small number of subjects, chosen somewhat arbitrarily, with the risk of falling on special cases, of acquired or hereditary habits which cause the average to vary so greatly that the number of observations is necessarily restricted because of the multiplicity of the determinations and of the complication of the experiments.

With regard to this third method, we must notice also that it is not quite certain that the total nitrogen is found again in the excretions, urine and fæces of the subjects examined, and that a part may under certain conditions be lost in a nitrogenous state, free or otherwise, by the lung and the skin. It is true that the experiments of Bidder and Schmidt, Ranke, Pettenkoffer and Voit (Zeitsch. f. Biolog., t. XVI, p. 508), and lastly Atwater, have established that in repose, at least, the greater part of the nitrogen is found again in the urine and fæces. But Seegen and Nowak (Pflüger Arch., t. XIX, p. 347, and t. XXVI, p. 292) have asserted the contrary, and for myself I shall raise the objection that the fact that nitrogen is not set free by perspiration and expiration requires to be confirmed, above all for the working individual.[1] All the nitrogen lost by these last processes and that lost by the epidermis and the hair escapes in the calculation of the respiratory balance and is counted as accumulated by the subject.

Lastly, and this is a serious cause of indefiniteness, it has been recognized that it is possible to vary in a sufficiently large degree the relative assessment of the foods which maintain the nitrogenous and carbonated equilibrium according as the subject is fat or lean, and according to the state and the nature of the reserves formerly acquired by him. Whilst preserving the nitrogenous equilibrium one is able, in the same individual, to change in the régime the relations between the albuminoids and the ternary bodies, an excess of the latter exercising on the former an economic action and vice versa. So that the proportions between the fundamental principles of alimentation which allow us to preserve a nitrogenous and carbonated equilibrium, can vary very much according to the actual state of the subject.

However that may be, by this third method, called *nitrogenous and carbonated equilibrium*, the average of different determinations has given, as the daily average ration of man undertaking only very light labour, or none at all :

[1] One will see that the urea augments from 2 to 4 grms. per day during work, while the alimentary ration increases from 25 to 35 grms. of albuminoids. In repose the excretion of nitrogen through the skin and lungs appears to be almost a negligible quantity.

Albumin	110 grms.
Fats	56 "
Carbo-hydrates	425 " [1]

If we now compare the means given by each of the three methods which we have just analysed we shall have :

	Alimentation calculated according to the average Parisian consumption.[2]	Alimentation calculated according to the free choice of some healthy subjects as types.	Alimentation according to the balance of nitrogen and carbon.
Albumin . .	102	110·2	110
Fats	56·5	80·9	56
Carbo-hydrates .	400	397·0	425

Of these three averages, the first seems to me to be the most accurate, that which has the greater weight, on account of twe enormous number of individuals upon which it is based. However, if we take count of the other two, which differ only very little from this one, we arrive at this definite conclusion, that in a *state of rest*, the average adult in health, has need for his daily maintenance of the following organic principles :

	Per day [3]
Albuminoids	107·3
Fats	64·5
Carbo-hydrates	407·5

Such is, in absolute and relative quantities, according to calculations which we can consider as very nearly accurate, the weight of the alimentary organic principles necessary every day to the average adult man of the races of Europe and North America, to keep himself healthy whilst furnishing only a minimum amount

[1] The average figure given by German authors is 345 grms., but in order to compare their calculations with mine it is necessary to take into account the alcohol absorbed not reckoned by them, and which for 1,250 cc. of beer daily at 4 per cent. (average quantity) represents 40 grms. of alcohol corresponding to 80 grms. of sugar.

[2] According to Pflüger and Bohland, Bleibtreu (Pflüger's Arch., t.XXXVI, p. 165, and t. XXXVIII, p. 1) the average of total nitrogen found in the urine during 24 hours of 99 adults (ordinary diet) has been 14·95 grms. We shall see later that with a mixed diet, 92 per cent. only of alimentary albuminoid substances penetrate into the blood and are made use of. To calculate the quantity of alimentary nitrogen which has been received by these adults it will be necessary to multiply 14·95 grms. by the fraction 100/92, which brings the nitrogen introduced by the foods to 16·25 grms. These weights multiplied by the factor 6·25 give (as we have already seen) the corresponding quantity of alimentary albuminoids in 24 hours. It is then, according to this average, 101·56 grms., a number which approaches singularly near to the 102 grms. which we found in giving an account of the entire alimentation of Paris. It is a remarkable confirmation of our average.

[3] Calculated for 100 albuminoids : 100 ; fats 61 ; carbo-hydrates 371.

of work or none at all. He needs every day about 107 grms. of albuminoids, 65 grms. of fats and 407 grms. of sugar or starch, a part of which (about one-fifth) can be replaced by half its weight of alcohol, as the observation of Paris proves, and as we shall fully establish later on.[1]

All the conclusions hitherto arrived at relate to the adult man. For the woman who is smaller, less heavy, and relatively richer in fat, we generally admit that her nutritive needs represent about four-fifths of those of the man. They will then be for her, on an average and per day:

Albuminoids	86	grms.
Fats	52	„
Carbo-hydrates	326	„

The proofs of the preceding averages, whatever may be the methods by which we have obtained them, are all liable to some objection: through atavism, habit, pleasure, it seems that one eats a little too much; and in consequence the averages obtained may all be slightly exaggerated, because of this abuse which has become part of our customs. In an interesting memoir which appeared in the *Bulletin Général de thérapeutique* (November, 1902), Dr. Bordet tries to prove that 60 to 80 grms. of albuminoids, 50 to 60 grms. of fats, 235 to 300 grms. of carbo-hydrates can suffice daily as a ration of maintenance for a man of ordinary weight; so that our alimentation has come to exceed the necessary and reasonable limits by about one-third. Prof. Maurel (of Toulouse) will accept a very slightly higher figure. In support of his opinion, M. Bordet states the case of a manager of a large industrial business, in excellent health, weighing 80 kilos, and living for the last twenty years (he is now 70) on the following ration:

Morning.—Cup of tea, 20 grms. of sugar: 15–20 grms. of milk; a roll (100 grms.).

Midday.—60–70 grms. of meat; 100 grms. of vegetables (in grain) or green; 100 grms. of bread; 15–20 grms. of cheese; a cup of coffee with 20 grms. of sugar.

Evening.—The same as midday with soup added and coffee omitted. 800 cc. to 1 litre of vinous water in 24 hours.

The calculation of this ration amounts to:

Albuminoids	63	grms.
Fats	53	„
Carbo-hydrates	245	„

To these facts I raise the objection that peculiarities and excep-

[1] With regard to alcoholic drinks we shall show the theoretical possibility and sometimes the necessity of this partial replacement of carbohydrates by their isodynamic weights of alcohol. For the moment we shall limit ourselves by drawing this conclusion from the observation of the facts of alimentation and particularly of the alimentation of Paris.

tions do not make the rule ; that, if it is true that some people can live and be healthy with the rations of a hermit, if it is good and logical to advise in general to reduce the régime rather than exaggerate it, we do not live any the less with the constitution that heredity and the needs of our race have transmitted to us. Is there much exaggeration in the modern habits of feeding ? Let us observe that, according to the facts and numbers that I have given above, the same nutritive balances result from the examination of the diet of the most diverse populations ; that, the needs of the greater number, i.e. workmen and peasants, are generally not stimulated but reduced by the moderate resources that manual labour procures for them ; to such a degree that the great majority receive only absolute necessities. There is certainly some exaggeration in the habits of those who are not limited by the bare necessities of daily life. In the case of these, the hygienist and the doctor might plead for sobriety ; but even for them, it would hardly be possible for these habits to disappear from one day to another without immediate discomfort. For certain persons at ease, for a few working populations accustomed, however, to good feeding, a little alimentary exaggeration constitutes almost a necessity, and as soon as the article of diet which seemed instinctively indispensable is diminished, the individual suffers, sometimes wastes away, does less work or seeks a temporary pick-me-up in alcoholic drinks.

We shall observe that the three kinds of fundamental principles of current alimentation, e.g. albuminoids, fats, carbohydrates, do not coincide in the normal proportions aforementioned in the study of the nutritive balance-sheet in any of the natural foods taken separately : neither meat, bread nor milk would be sufficient in this case to satisfy us. The fundamental alimentary principles are included indeed in the following statement that I have calculated for 100 per cent. of albuminoids :

	Albuminoids.	Fats.	Carbohydrates.
Average normal alimentation	100	59	385
Muscular flesh	100	28	0·3
Bread	100	65	750
Milk	100	99	118
Milk and bread in equal parts	100	52·5	434
1 part of meat and 3 parts of bread	100	12	562

Thus neither milk nor bread nor a diet composed of bread and meat, in whatever proportions, can provide us with the fundamental alimentary principles under normal relations *deduced from the observation of facts.* Alone milk and bread, taken in equal parts, satisfy the requisite relation between proteid matters

and ternary alimentary substances. It is well known besides that we can live almost indefinitely on bread and milk.

It remains now to ask if the three kinds of nutritive organic principles that one finds in all complete and free alimentation are really indispensable, if their association in these proportions, determined by the examination of facts, is not a little fortuitous, and if certain of these principles could not make up the one for the other. The isodynamics or equivalence of food is a very important question which will be treated farther on. For the moment we will simply note that in four countries—France, Germany, England and the United States—where alimentary customs are sufficiently different, physiologists and modern hygienists have all arrived, by methods often very dissimilar, at averages which agree so well and at almost identical relations between the quantities of the fundamental alimentary principles which enter into the ordinary ration of a healthy man. For 100 parts of albuminoids, experience has shown us that 50 to 68 grms. of fatty substance and 366 to 386 grms. of actual carbo-hydrates (alcohol not included) are necessary, or adding up the ternary compounds, a little more than $4\frac{1}{2}$ times the weight of the albuminoids is needed.

But a detailed study of the alimentary ration enables us to go still farther: in the alimentation of a Parisian, out of 102 grms. of albuminoids, 56·3 grms. or 55 per cent. are furnished by the animal kingdom and 46·7 or 45 per cent. by the vegetable kingdom. In the nourishment of four vigorous and hale artisans, Uffelmann found that the animal albumin was to the vegetable in the proportion of one to two. In the cases of two labourers at light work, C. Voit observed that 47·5 per cent. of albumin was furnished by meat and 52·5 per cent. by bread. One can then make the general statement that satisfactory relative proportions of flesh, bread and vegetables are those which provide us with, from 40 to 60 per cent. of albuminoids by means of animal food and 60 to 40 per cent by means of vegetable food. Every régime which introduces more than 60 per cent. of its nitrogen in an animal form is too rich in flesh and disposes to arthritis, gout and eczema, etc.; to these many morbid states it exposes all those at least who do not correct the excess of foods or muscular flesh by sufficient muscular exercise, especially those who lead a sedentary or cloistered life or who overtax the mind.

We have already remarked, à propos of the average alimentation of Paris, that foods of animal origin form in weight about the fourth of those of vegetable origin, alimentary drinks included, and a third if we do not include in this calculation wine and beer, In this alimentation which has given us these proofs, we find then for 100 parts:

Foods of animal origin	23 parts
Foods of vegetable origin (bread, vegetables, green or dry, etc.)	44 ,,
Wine (650 cc. per day)	33 ,,
	100 parts

These relations would be a little different if the wine were replaced by a quantity of beer or cider of an equivalent alimentary value. We shall see later on how the relations which we have just experimentally established can be usefully modified, and in what cases.

IV

MINERAL SALTS NECESSARY TO THE HUMAN SYSTEM—PRINCIPAL ACCESSORIES, USELESS OR HARMFUL

MINERAL SALTS NECESSARY TO THE SYSTEM

CHLORIDE of sodium, the phosphates of potash, soda, lime and magnesia, the sulphates, the oxides of iron, with a little silica, fluorides, etc., are found in a constant manner in the residue left by the combustion of our organs and liquids. Their elements: chlorine, phosphorus, sulphur, potassium, sodium, calcium, magnesium, iron, silicon, fluorine, etc., united amongst themselves and to the other organic matters of the protoplasms and humours, form, so to speak, the mineral skeleton of the constitutive protoplasms functioning in the cells. These mineral principles are then absolutely indispensable to the tissues.

Volkmann, in the corpse of a man weighing 62·5 kilogrammes, found the weight of the ashes to be:

The skeleton	2,247·3 grms.
The soft parts	468·3 ,,
Total	2,715·5 grms.

The total weight of the mineral compounds exceeds then 4·3 per cent. of the weight of the whole human body, and the alkaline or earthy salts form about 0·76 per cent. of the soft tissues. The bones and cartilages contain five-sixths of the total of the mineral salts of the body; whilst the whole of the soft or liquid parts do not give more than 450 to 460 grms. of saline substances.

Evidently it is necessary that we should find in our different foods all these mineral matters in sufficient quantity and under assimilable forms, for the system is continually impoverishing itself of them by its excretions, particularly by the urine.

These saline materials exist, besides, in different quantities in the several organs, but their proportion varies very little in the organ of one individual and that of another. In the blood, the salts vary from 0·9 to 1·3 per cent.; in the muscles, from 0·9 to 1·2; in the fresh bone, from 34 to 37 per cent. of fresh matter.

The following table indicates the proportions and the nature of the mineral substances entering into the composition of some of the principal tissues and humours of the system.

MINERAL MATTERS CONTAINED IN THE PRINCIPAL PARTS.
(For 1,000 fresh parts; except bone.)

	Muscle of the Mammifers.	Nervous Substance.	Dry Bones.	Hepatic Gland.	Globules of 1000 cc. of blood.	Plasma of 1000 cc. of blood.	General Lymph.
Mineral matters in 1000 grms. of the fresh substance containing :	grms. 9–12	grms. 2–7	grms. 620–690	grms. 9–11	For 1000 cc. of blood. Total. 7·5–10·12 grms.		grms. 7·47
Chlorine .	0·5–0·7	0·4	0·6–0·7	0·25–0·42	0·36–0·9	1·7–1·4	3·08
P^2O^5 . .	3·4–5	0 85–1·4	196–247	5·02–4·27	0·69–0·65	0·71–2·2	0·18
SO^3 . .	2·2	0·14	0·20	0·09–0·092	—	—	0·09
SiO^2 . .	—	—	—	0·027–0·018	—	—	—
K^2O . .	3–3·9	0·71–2·12	—	2·52–3·47	1·6–1·4	0·15–0·20	0·16
Na^2O .	0·4–0·7	0·75–1·3	—	1·45–1·13	0·24–0·65	1·66–1·9	3·07
CaO . .	0·9–0·18	0·03	270–500	0·36–0·03	0·19–0·25	0·06–0·08	0·15 (CaO and MgO together)
MgO . .	0·4	0·065–0·75	4–6	0·02–0·007	0·07	0·02–0·05	
Fe^2O^3 .	0·03–0·02	0·04–0·12	—	0·27–0·17	0·77	0·006	—
CO^2 . .	—	0·21–0·33	3·2–4·5	—	—	—	0·50

These mineral elements exist in our tissues in part under the same forms under which they eliminate themselves by urine, fæces, epidermic desquamation, etc., in part, and especially, in the state of complex organic combinations, like sulphur in the albuminoids, phosphorus in the nucleins, the lecithins and the tetramethylenephosphoric acid, etc. ; or like magnesium in the nervous tissue and in chlorophyll, iron in the haemoglobin of the blood and in the hematogen of the egg.

Indispensable to functioning, these mineral elements are then necessary to the life of the cell, and alimentation ought to be able to supply us with them under assimilable forms and in sufficient quantities in the same measure as it furnishes us with organic principles, albuminoids, fats or starches.

J. Forster has besides established that mice, pigeons, dogs fed with an excess of meat which has been drained of its salts by hot water, even if one adds to this meat, together or separately, starch, sugar, and the necessary fats, do not live beyond twenty to thirty days. Deprived of mineral matters, these animals behave almost as if they had been absolutely starved.

We eliminate in twenty-four hours by the kidneys, perspiration and the fæces, the following quantities of mineral matter :

	Urine during 24 hours.	Fæcal Material during 24 hours.[1]	Perspiration during 24 hours.	Average per day.
	grms.	grms.	grms.	grms.
Water	1,300–1,350	100–119	600–750	—
Total saline material . .	17·3–21	4·35–6	1·3–20	25·9
These saline materials contain—				
Chlorine	4·9–7·2	0·015–0·035	1·12	7·4
Phosphoric anhydride (P^2O^5)	1·6–3	0·76–0·82	Traces	3·05
Sulphuric anhydride (SO^3)	1·8–2·8	0·060–0·17	0·005	3·00
Silicic anhydride (SiO^2) .	0·003–0·004	0·17–0·35	—	0·26
Carbonic anhydride (CO^2)	—	0·05	—	—
Potassium oxide (K^2O) .	1·6–3·1	0·75–0·30	0·178	2·88
Sodium „ (Na^2O)	4·16–5·9	0·25–0·35	0·80	5·60
Calcium „ (CaO) .	0·25–0·36	0·65–0·70	Traces	0·85
Magnesium „ (MgO) .	0·56	—	„	0·56
Iron peroxide „ (Fe^2O^3)	0·004–0·013[2]	0·023–0·040[3]	—	0·004
Average weight of mineral material in 24 hours	19·6 grms.	4·3 grms.	2·0 grms.	

Of these principles some are eliminated just as they existed in the plasmas and tissues ; others as SO^3, P^2O^5, MgO, Fe^2O^3, and perhaps SiO^2, arise either from hydrolytic divisions of the constituent principles, or from the oxidation of sulphur, phosphorus, silicon, magnesium, iron, etc., closely united to certain organic principles. Others are excreted under complex forms insufficiently determined, by loss of hair from the head, from the epidermis, and by the extractive matters of the urine, etc.

It is thus that, be it in the state of mineral matters properly so called, or under the form of mixed compounds, we lose every day from 24 to 28 grms. (26 grms. on an average) of mineral substances, about half composed of sodium chloride, the rest being represented especially by phosphate and sulphate of potassium and by the corresponding salts of soda, lime and magnesia in a far less proportion. Each day 1·2 grms. to 1·5 grms. of sulphur and an average of 1·1 grms. of phosphorus are thus ejected as mineral salts. To these salts it is necessary to add some milligrammes of iron and silicon and some hundredths or thousandths of a milligramme of arsenic, copper, manganese, iodine, bromine, boron, etc. These last elements are eliminated thanks especially to epithelial desquamation or by the hair of the body and head.

Our daily alimentary ration ought then to be sufficient and varied enough to bring to us the complex *ensemble* of these mineral foods, and in assimilable forms.

[1] According to Bischoff and Voit, and for the fæces of dogs ; but the quantity of matter and of water here calculated are those of human fæces after Wehsarg.

[2] According to Magnier de la Source.

[3] According to Lapicque (C.R. Soc. Biolog., April 3, 1896).

It is evident that in the normal state it provides us with them, at least for the major part, since the preceding statistics are founded on the observation of the excretions of the healthy adult provided that he feeds himself in an average way. So that in order to establish the importance of the mineral dissimilation, we have only affirmed definitely that which occurs in ordinary alimentation which may vary perhaps very much. But we know to-day that potash and the phosphates form an integral and necessary part of all the vegetable or animal cells; chloride of sodium, of all the plasmas; iron, of the globules of the blood; iodine, of the thyroid gland; arsenic, of the ectodermic tissues; bromine, of the skin and hair, etc. These elements are specific, localized and consequently indispensable, whence, still upholding this point of view, the necessity and the rôle of a variety of foods. It explains the instinct which makes us have recourse to the many alimentary sources each one of which provides us with some of the elements which, like magnesium, manganese, iron, arsenic, iodine, bromine, silicon, etc., are far from being widespread and under acceptable forms.

We will enlarge further on, in a chapter specially devoted to this important subject, upon the composition, origin and working of the principal minerals of the economy; but it seems, at this stage, instructive to state what is the quantity of ordinary saline materials which average feeding, such as we have defined it for Paris in particular (p. 11), brings to us. The following table gives the results of a calculation which I have made on this subject:

MINERAL MATTER IN AN AVERAGE DAILY ALLOWANCE OF FOOD.

Kind of Food.	Weight per day.	Corresponding Mineral Matter.
Bread and dough	420 grms.	3·10 grms.
Meats	216 „	2·48 „
Milk	213 „	1·33 „
Eggs	24 „	0·22 „
Fresh fruits	70 „	0·55 „
Fresh vegetables	250 „	2·70 „
Dry vegetables	40 „	1·10 „
Potatoes	100 „	1·00 „
Cheese	8·1 „	0·22 „
Sugar	40 „	0·25 „
Butter	28 „	0·02 „
Wine (calculated at 10 per cent.)	557 „	1·54 „
Drinking water	1 litre	0·30 „
	Per day	14·81 grms.

To these 14·81 grms. of mineral materials conveyed by the daily foods and drinking water, one must add 8 to 10 grms. of salt which we mix daily and directly with our dishes, which

makes a total weight of 24 grms. of saline materials. On an average, as we have seen, we excrete of the latter 25·9 grms. by the urine, perspiration and epidermis, etc. The small difference is due to the fact that a part of the organic sulphur and phosphorus is lost by combustion owing to a small error of appreciation.

One will observe in the average allowance of food, the enormous portion of mineral materials of vegetable origin. Of the 14·3 grms. of salts and salifiable substances introduced by aliments (besides the salt added), vegetables furnish us with 10·24 grms., or 69 per cent. Being given the considerable quantity of organic phosphorus and sulphur which we derive from this source, and the part played by the alkaline and earthy bases with which plants also provide us in the form of combustible acid salts, salts from which the tissues and plasmas especially take their alkalinity, as will be shown later, one sees the important part which, from this point of view, foods of vegetable origin play in the process of alimentation.

Plants bring us especially potassium, magnesium and phosphorus, very little chlorine and sodium, lastly a quantity of lime which is scarcely a tenth part of the weight of the alkaline bases.

We shall again refer with care to the part which each of these mineral elements plays in the animal economy. At present it is sufficient to show in what proportion they enter into general alimentary statistics.

ACCESSORY ALIMENTARY ELEMENTS—DOUBTFUL OR HURTFUL SUBSTANCES.

As fundamental alimentary elements we find, as we have said, in our food stuffs, as in our tissues, albuminous materials phosphorated and non-phosphorated, fats, carbo-hydrates and similar substances, water and the salts of which we have just spoken. But one must not think that all the albuminoid bodies, all the fatty elements, all the sugars and other carbo-hydrates are suitable for our food. Everything is alimentary which, penetrating into the digestive tract, can be transformed into constitutive elements identical with those of our tissues, or everything which is to provide us with disposable energy after having entered the blood.

Many albuminous substances do not possess these aptitudes, or only possess them very relatively and only in connexion with certain very specialized tissues. Thus, the ossein of bone, the chondromucoid of cartilage, elastin, etc., elements digestible and partly soluble in the intestine, appear very feebly suitable to nourish the living protoplasms, at any rate as far as man is concerned. The fact is, that these substances existing almost exclusively in a few special tissues, as bony tissues, cartilaginous, conjunctive, fibro-elastic, etc., tissues whose nutrition is rather slow,

are not transformable in the system into ordinary albumins (serin, musculin, fibrin, etc.) or are not so without loss or great difficulty. A certain quantity of gelatin can be absorbed and utilized, but the greater part of this substance, *if one consumes it in abundance*, is finally destroyed or only serves, after the manner of fat or starchy matters, to protect the albuminoids of the ordinary tissues, of the muscular flesh, and of the blood, etc., albuminoids which it does not seem able to appreciably reproduce. Gelatin can even prevent the loss of fat; it permits the animal to perform its functions with a less ration of albuminous substances, but it cannot be entirely substituted for these, even if one gives it in super-abundance. Nevertheless, so long as it does not exceed the sixth or fifth of the absorbed albumins, one can consider gelatin as nearly equivalent to albumin, at least for young animals, as I have shown.

Of the other albuminoids such as mucin, conjunctin, keratin, chitin, elastin, etc., man does not seem able to assimilate them. This shows clearly that it is not sufficient that a substance, even *digestible* or *soluble* in the intestine, like elastin, should be nutritive in order to form part of our tissues.

The nucleoproteids which especially form the nucleus of our cells, and the cyclo-proteids of the protoplasms, are they assimilable? They hydrolyze in contact with the pancreatic and intestinal juices, and a part of their phosphoric acid is found again in the urine.[1] It appears then that they ought to contribute to the formation of the phosphorated albuminoids of the system. But the proof is not yet completely established. I shall say just the same of the lecithins and the jecorines; nevertheless, their presence in the yolk of the egg and in fat appears fairly to indicate that they play an alimentary part, at least for young cells, in the process of formation.

The nitrogenous products of the decompositions of the albuminoids, animal and vegetable, such as the complex amides, asparagins, lecithins, puric bases, extractive matters of soup, etc., appear some to be indifferent, others active; these latter, no longer in the manner of ordinary foods, but like veritable nervous stimulants. We shall come back to them when on the subject of nerve foods and condiments.

Some decomposable matters whether nitrogenous or not, produced by certain cells, are transported by the blood and react like active ferments or as modifiers of the assimilable substances. Others, resulting from the division of much more complex bodies, or of a kind of dissimilation of certain tissues, help to the fulfilment of different functions: such is the case of glycogen and

[1] Gumlich Zeitsch. f. Physiolog., Bd. XVIII., p. 508;, Popoff, *ibid*, p. 53.

glucose formed particularly in the liver by the division of its special materials, and which, poured into the blood, serve to contract the muscles and to maintain animal heat. The fats produced in the cells have almost the same origin and the same destiny.

In general, the excretory matters not only are not alimentary whatever their composition may be, but they even hinder the functions as soon as they accumulate in the tissues; such as urea, the puric bodies (uric acid, allantoin, sarcin, guanin, carnin, etc.) the leucomaines (cholin, neurin, protoamines, etc.); amiro-acids (glycocol, leucin, taurin), indol, indogen, etc.

Among the non-nitrogenous organic substances, the carbohydrates are all far from being able to provide for human alimentation. The ligneous materials which the insect xylophagus eats, cellulose which nourishes the herbivora, the wool on which the larva of insects feed, etc., do not suit us, or at the least, as regards cellulose, for example, only assimilating very imperfectly and only certain kinds. Kniriem has observed, in himself, that man only absorbs on an average 25 per cent. of the cellulosic tissues of new formation (salad, fresh vegetables). Mucilages, gums do not seem suitable, or are only with great difficulty and partially fit to be utilized. It is generally thus with all the sugars, and carbohydrates, aldehydic or acetonic, as well as the corresponding alcohols which have per molecule a number of atoms of carbon which is not a multiple of three: tetroses or erythroses $C^4H^8O^4$, pentoses $C^5H^{10}O^5$, heptoses $C^7H^{14}O^7$, etc. (E. Fischer).

The bodies called *aromatic* or *cyclic* are generally unassimilable; but certain of them can play the part of stimulants or, quite on the contrary, of inhibitors of the vital functions. Such are the aromatic alcohols, natural alkaloids, colouring matters, vegetable or animal, hydrocarbons, phenols, true essences, etc.

As to ordinary alcohol, alcohol of wine and beer, we shall see farther on that it can supply the system almost entirely with the chemical energy which it contains in the latent state and which in consequence should be considered as alimentary, although this may be an aliment of a very special order; at the same time a producer of energy and a nerve stimulant.

Vegetable or animal, the fats formed by the mixture of different ethers of glycerine (butyrin, margarin, stearin, olein, etc.) are all alimentary. It is not the same of different bodies of a fatty kind but which have not glycerine as a foundation; such as the ethers of spermaceti, those of cetylic alcohol obtained from Chinese wax or of melissic alcohol of bee's wax, etc. Although combustible and fatty, these bodies and their derivatives are not assimilable.

With greater reason, the hydrocarbons properly so called (olefines, vaselines, etc.) are not assimilable. All these bodies are incapable of being assimilated and of being converted into animal substances.

We shall see, on the contrary, that the salts of the fatty acids and similar acids (acetates, butyrates, stearates, oleates, . . of potash, soda, lime, etc.) the citrates, malates, alkaline tartrates, etc., and the fatty acids themselves, substances which vegetables provide us with in sufficient abundance, fruits and some animal products, etc., are real foods. They become oxidized in the system in giving us caloric energy, whilst from their combustion arises carbonic acid, water and soluble carbonates or bi-carbonates, which alkalize the fluids and thus insure oxidation and the performance of the general functions.

V

DIGESTIBILITY AND COEFFICIENT OF UTILIZATION OF FOODS—ASSIMILATION OF THE DIFFERENT NUTRITIVE PRINCIPLES

IN the preceding chapters we have shown, both by statistics and calculations, what are the proportions and the nature of the principal organic and mineral materials which his daily food furnishes to man at rest. But in order to know the effective quantities which really reach our organs, whether as assimilable and plastic materials or as useful sources of energy, it is necessary to determine for each principle the percentage quantity which traverses the intestinal walls to be poured into the circulatory stream and reach the organs.

DIGESTIBILTY OF THE ALIMENTARY PRINCIPLES.

In passing through the digestive tube, the alimentary materials undergo the action of the salivary ferments, likewise those of the stomach and intestine, and are transformed, but only in part, into substances fit to be reabsorbed by the intestine and to penetrate into the lymphatics and the blood. These substances, from that time, are not yet *assimilated* but *digested* ; and one can for each aliment or alimentary principle measure this digestibility by the inverse of the time which has been required to transform it into materials fit to traverse the intestinal walls.

The comparison of the digestibility of principles of the same kind is especially interesting : starches of different natures and origins, dextrins and special sugars, different fats, animal and vegetable oils ; albuminous principles originating from different organs ; aliments borrowed from animals or plants which have undergone certain preparations, such as for example meat—raw, boiled, roast, smoked, etc.

It is necessary to distinguish between the digestibility of the stomach and that of the intestine, the ferments of these two organs acting differently on each alimentary principle ; that which happens in the first being in no way able to serve as a measure of that which takes place in the second. So, I will here only briefly refer to the ideas of Leube on digestibility. Examining hour by hour, by means of the gastric pump, the contents of the stomach, Leube classified the aliments according to the rapidity with which they passed from the stomach into the

intestines. Broth, boiled eggs and biscuits formed the most digestible group. Whipped eggs, the flesh of fowl and pigeon stewed, brains, sweetbread, tapioca and semolina soups constituted the second. Grated uncooked beef, minced ham, beefsteak lightly grilled, purée of potatoes, stale bread, café-au-lait, etc., the third. Fowl, pigeon, young partridge roasted, cold roast beef, roast veal, eggs buttered or in omelettes, boiled fish, rice cooked in water, macaroni, spinach, baked apples, white or red wines diluted with water, formed the fourth group. All this appears to us very arbitrary. But who does not know that different foods are more or less digestible according to the particular stomach ; that there are those who digest milk with more difficulty than meat ; that raw meat is generally much better tolerated (provided that one swallows it without disgust and without chewing it) than boiled meat, fowl and especially pigeon ; that boiled fish is very often digested by convalescents who cannot bear beefsteak, eggs or macaroni ? I have known a lady who suffered from uncontrollable vomiting during pregnancy, and having been prematurely delivered, could not digest anything, after a compulsory diet extending over three weeks, except strawberries and crayfish—each, it is true, in a small quantity. I have seen during the Siege of Paris, a young man taken with vomiting while fully and easily digesting horse-flesh pie, because a sorry jester suddenly declared that he had just been eating some rat from the sewer. Digestibility of foods, one has known for a long time, but especially since Pawlow's experiments, is largely influenced by stomachic reflexes, habits, and even, as one has just said, by the psychic states which accompany their digestion.

Thus is explained the differences created by atavism and education. But idiosyncrasies put on one side, I think that in a healthy man, stomachs are on the average nearly the same in every country ; and that a Marseillais, a Parisian or a Flamand, if they had each been taken from home or accustomed to them from childhood, could have been brought up to easily digest the dishes of the country to which they had been transplanted. Nevertheless, give a Marseillais butter pap or beef soup, to a Flamand garlic soup, to a Parisian the aïoli of Marseilles or the dried fish of the fishers of Dunkerque, and you will provoke in any of them disgust or indigestion. Recollections and ideas which accompany such and such aliments influence in such a degree their acceptation by the stomach and their digestibility, that these psychic states can change entirely, and for a considerable time, the digestive aptitudes of the individual. I have been witness of the following facts. A young child, aged seven, being forced to eat, whilst ill, some salad which he nevertheless liked, had an attack of indigestion and during more than ten

years he remained absolutely unable to digest this food of which he had formerly eaten very freely. A little girl, aged five, having been given some ipecacuanha in her coffee, took such a dislike to the latter that its odour alone provoked nausea and from that time she could not bring herself to absorb the least quantity of a drink which she had looked forward to before this event.

With these exceptions and only taking into consideration the most ordinary conditions, it is necessary that the physician should be informed of the average time which, in ordinary circumstances, the stomach demands for the digestion of such and such alimentary materials. The stomach ought only to receive, in general, fresh foods after the preceding repast has been disposed of. In this respect the following observations, due to Penzoldt, present a practical interest :

AVERAGE TIME NECESSARY FOR THE STOMACH TO REMOVE THE DIFFERENT ALIMENTARY MATERIALS WHICH IT DIGESTS TO THE INTESTINE.

	Quantity in grms.	Time in hours.
A. Waters and Alimentary Drinks.		
Pure or gaseous water	100–200	1 to 2
	300–500	2 ,, 3
Infusion of weak tea	200	1 ,, 2
Coffee	200	1 ,, 2
Coffee with cream	200	2 ,, 3
Pure cocoa	200	1 ,, 2
Cocoa with Milk	200	1 ,, 2
Beer	200	1 ,, 2
	300–500	2 ,, 3
Light wine	200 cc.	1 ,, 2
Ordinary wine	200 cc.	2 ,, 3
Malaga wine	200 cc.	2 ,, 3
Gravy soup	200 cc.	1 ,, 2
B. Flesh of Mammals or Birds.		
Cooked beefsteak, hot or cold	100	3 ,, 4
Roast beef	250	4 ,, 5
Roast fillet of beef	100	3 ,, 4
Raw beef (lean)	250	3 ,, 4
The same boiled	250	3 ,, 4
Raw ham	160	3 ,, 4
Cooked ham	160	3 ,, 4
Roast veal, hot or cold (lean)	100	3 ,, 4
Smoked meat	100	4 ,, 5
Smoked tongue	250	4 ,, 5
Sausage of raw meat	100	2 ,, 3
Roast hare	250	4 ,, 5
Roast goose moderately fat	250	4 ,, 5
Roast duck	250	4 ,, 5
Roast partridge	230	3 ,, 4
Boiled pigeon	230	3 ,, 4
Roast pigeon	195	3 ,, 4
Boiled or roast chicken	250	3 ,, 4

	Quantity in grams.	Time in hours.
C. Other Dishes derived from Animals.		
Sweetbread	250	2 „ 3
Boiled calf's foot	250	3 „ 4
Calf's brain	250	2 „ 3
Boiled milk	100–200	1 „ 3
	300–500	2 „ 3
Soft-boiled eggs	100	1 „ 2
Hard-boiled eggs or omelettes	100	2 „ 3
Gravy Soup	200	1 „ 2
D. Fish and Analogous Dishes.		
Boiled carp	200	2 „ 3
Boiled pike	200	2 „ 3
Boiled haddock	200	2 „ 3
Fresh boiled cod	200	2 „ 3
Lamprey with vinegar	200	3 „ 4
Boiled Rhine salmon	200	3 „ 4
Salted or smoked herring	200	4 „ 5
Salted caviare	72	3 „ 4
Raw oysters	72	2 „ 3
E. Cooked Vegetables.		
Steamed potatoes eaten with salt	150	2 to 3
Mashed potatoes	150	2 „ 3
Potatoes with vegetables	150	3 „ 4
Boiled cauliflower	150	2 „ 3
Cauliflower cooked in salad	150	2 „ 3
Cooked asparagus	150	2 „ 3
Rice cooked in water	150	3 „ 4
Cooked turnips	150	3 „ 4
Boiled carrots	150	3 „ 4
Boiled spinach	150	3 „ 4
French beans	150	4 „ 5
Mashed peas	200	4 „ 5
Mashed lentils	150	4 „ 5
Green peas cooked in water	150	4 „ 5
F. Raw Vegetables.		
Cucumber salad	150	3 „ 4
Raw radish	150	3 „ 4
G. Bread and Biscuit.		
White bread, fresh or stale, dry or with tea	70	2 „ 3
	150	3 „ 4
Rye bread	150	3 „ 4
Albert biscuits	50	2 „ 3
	150	3 „ 4
H. Fruits.		
Apples	150	3 „ 4
Raw cherries	150	2 „ 3
Stewed cherries	150	2 „ 3
Cocoa (cup of)	200 cc.	1 „ 2

With all reservation as to the preceding remarks, we see that the foods which pass most quickly from the stomach into the

intestine are the alimentary drinks (café-au-lait, light chocolate, wine, beef-tea, vegetable broths, etc.); after these come milk, either boiled or not, eggs, cooked fruits, biscuits, brains, sweetbread and boiled fish. Next are placed rice, herbaceous vegetables and, nearly in the same rank, meat raw or cooked, and fowl. Fat meats, game, salt fish and some vegetables are difficult to digest; finally very fat fish are the least digestible. This indeed is what ordinary observation has already taught us.

The forms under which foods are presented influence to a large extent the appetence and digestibility of various dishes. This is the rôle of culinary preparations, of spices and of fermented liquids. We shall return to this. In general, the form which permits of the most rapid digestion is that which, for the same aliment, presents it as finely divided as possible. Emulsions, milk, cooked cocoa, etc., are in this category. Even the manner in which an alimentary substance is swallowed largely influences its digestibility. Give to a subject accustomed to raw meat, this alimentary matter under the form of pulp to take with a teaspoon, at the beginning of a meal, you will rapidly induce in him satiety and want of appetite for the foods which are to follow. Try the contrary, first let him eat these same foods and give afterwards, at the end of the meal, this same quantity of raw meat, pulped, in large balls of 20 to 30 grms. each, watching that it is swallowed without being chewed, in the second case you will neither provoke disgust nor satiety. The subject will succeed in digesting perfectly that which, taken otherwise or in the opposite order, would have provoked distressing reflexes, and for a long time have remained in the stomach.

Because they have left this organ and penetrated into the intestine, foods are not for that reason digested; but intestinal digestion escapes direct observation, it has therefore been agreed to measure the digestibility of each food in the inverse ratio to the time necessary for stomachic digestion. We admit that it lasts from four to six hours for the whole of a normal meal and that an interval of six to seven hours is sufficient between two meals. Still this time varies much: it becomes singularly shorter in cold climates, with exercise or physical work, in men of different ages and especially in a child who digests much more rapidly.

COEFFICIENTS OF INTESTINAL UTILIZATION OF FOODS.

It is very important to determine for each food and each régime the quantum which, under ordinary conditions, is utilized and reabsorbed in the intestine, and the proportion which remains undigested to be thrown out of the body. According to Rübner's experiments, we find that 5·5 per cent. of the organic matters

of an average mixed diet are excreted as fæces.[1] For a normal diet composed of 107 grms. of albuminoids, 64 grms. of fats and 321 grms. of true carbo-hydrates [2] this coefficient, for the total weight of 492 grms. of alimentary matter, calculated dry, would give 27 grms. of organic fæcal residue. Thus, according to Wehsarg, on an average we reject 140 grms. of excrements every day. This corresponds to 35 grms. of dry residue, containing 5·3 grms. of different insoluble salts which brings the organic residue of the fæces to 28·7 grms. Again there enters into this residue a certain proportion of cellulose and other organic indigestible matters. It appears then that Rübner's coefficient of inutilization (5·5 per cent.) is a little too high; it should not sensibly exceed 5 per cent. for a good diet and normal digestion. We shall see that Atwater arrived at 4·5 per cent. in the case of normal alimentation.[3]

This coefficient, variable according to the alimentation, being established for a well defined ration, in order to determine the quantum of utilization of each kind of alimentary matter, Rübner reduces this ration in a known proportion and replaces this deficit by foods of which he wishes to study the coefficiency of absorption. By deducting from the weight of the excrements that which corresponds to the retained portion of the primitive ration, one has, in the difference, the weight of the excrements proceeding from the addition of the food, the digestibility of which we wish to study, and in consequence the percentage weight of it which has been absorbed. As to the utilization of each of the albuminoid principles, fat or starch, composing the aliment under study, it follows: first, from the dosage of the quantity of excrementitial nitrogen which permits of calculating proportionally the residuary albuminoids and, by difference, the proportion of it which has been reabsorbed in the intestine, and secondly, from that of the fats or carbo-hydrates with which the fæces are enriched under the influence of the modification

[1] Between the two series of foods for examination Rübner, in order to be certain of the fæcal matter belonging to each series, gave several days following some milk which discolours these matters, and allows one to recognize and thus to separate the excrements corresponding to the different consecutive experiments. It was still better, as Cramer did, to make the patient take a little lampblack or animal charcoal, which visibly separates each excrementitial series.

[2] One must separate from the weight calculated 407·5 grms., that corresponding to the alcohol of the fermented drinks, weight which we have added under the form of glycose about 96·5 grms. There remains then 321 grms. of pure carbo-hydrates.

[3] A man in a state of inanition still excretes nearly 2 to 2·5 grms. a day *calculated in the dry state*, of fæces containing 0·1 to 0·3 of nitrogen. The result is that the calculation relative to the food used, deducting the nitrogen thus secreted in the state of intestinal mucous material, gives too low numbers.

introduced into the normal supply of food. All that which is not recovered in the excrementitial matters has been absorbed. We shall return to this subject at the end of this book.

By proceeding thus, Rübner, Prausnitz, E. Meyer, Woroschiloff, Ranke, von Noorden, Zuntz and Magnus Levy, Uffelmann, Atwater, etc., have arrived at the results which I reproduce in the following tables :[1]

TABLE OF INTESTINAL UTILIZATION OF ALIMENTARY PRINCIPLES ACCORDING TO RÉGIME (EXPERIMENTS ANTERIOR TO THOSE OF ATWATER).

	Weight of the alimentary substances calculated in the fresh state.	Weight of the alimentary substances calculated in the dry condition.	Weight of excrement in the fresh condition.	Weight of excrement in the dry condition.	Per 100 parts of the dry substance rejected by the fæces.	Proportion utilized for 100 parts.				
						Of Dry Material.	Of Albumin	Of Fats.	Of Carbo-hydrates.	Of Salts.
A. Simple Aliments (Rübner) .	gr.	gr.	gr.	gr.	gr.					
White bread . . .	1237	779	109	28·9	3·7	96·3	79	—	99	93
Rye bread . . .	1360	773	815	115·8	15·0	85·0	68–78	—	89	64
Macaroni	695	626	98	27·0	4·3	95·7	83	94	99	76
Rice	638	660	195	27·2	4·1	95·9	80	93	99	85
Milk	2438	315	96	24·8	8·8	92·2	89–99	96–97	100	63
Whole eggs . . .	948	247	64	13·0	5·2	94·8	97	95	—	82
Cooked meat . . .	1172	307	53	17·2	5·6	94·2	97	95	—	82
Potatoes	3078	819	645	93·8	9·4	90·6	78	—	93	—
Mashed potatoes with butter	—	—	—	—	—	95·0	80	—	96	—
Boiled savoy cabbages	3831	494	1670	73·8	14·9	85·1	—	—	—	—
Carrots	5133	412	1092	85·0	20·7	79·3	—	—	96	—
Mashed peas . . .	—	—	—	—	—	91·0	83	—	—	68
Fats	—	545	299	46·5	8·5	91·5	—	—	—	—
B. Complex Alimentation.										
Diet	—	615	131	34·0	5·5	95·4	86·6	94·4	97	85·4
{ Milk . . . . . { Cheese	2291 } 200 }	420	98	27·3	6·0	94	96	97	100	74
1 litre of milk, 300 grms. of meat, 175 grms. of white bread, 60 grms. butter.	1540	—	—	—	—	—	94	95	99	—

[1] On the subject of these researches see Rübner, *Zeitsch. f. Biolog.*, Bd. XV, p. 115, t. XVI, p. 119. Ranke, *Die Ernährung des Menschen* (1877), p. 31 ; Prausnitz, *Zeitsch. f. Biolog.* Bd. XXV, p. 533 ; Bd. XXVI, p. 231 ; Bd. XXX, p. 354 ; Zuntz and Magnus Levy, *Pflüger's Arch.*, Bd. XLIX, p. 438 ; Bd. LIII. p. 544. Uffelmann *Pflüger's Arch.*, Bd. XXIX. p. 339, etc. Atwater, *Nutrition investigations*, Annual Report, Bd. S., June 30, 1901, p. 470.

	Weight of the alimentary substances calculated in the fresh state.	Weight of the alimentary substances calculated in the dry condition.	Weight of excrement in the fresh condition.	Weight of excrement in the dry condition.	Per 100 parts of the dry substance rejected by the fæces.	Proportion utilized for 100 parts. Of Dry Material.	Of Albumin.	Of Fats.	Of Carbo-hydrates.	Of Salts.
Meat, peas, biscuits, cheese, rice, butter, beer.	4500	805	—	—	—	91·0	83	85	96	72
Meat, oatmeal, potatoes, bread, fresh butter, cheese.	4330	787	—	—	—	87·0	78	77	91	9
Soup, macaroni, vegetables, potatoes, white bread, meat (8 exps. Manfredi).	—	—	—	—	—	93·2	81·4	87·6	95·9	—
Rye bread, salted meat, milk, butter, cheese, potatoes, beer (Johansen).	—	—	—	—	—	92·4	90·6	94·5	94·7	71·5
Diet of Italian students : bread, meat, fish, eggs, potatoes, rice, peas, wine (Serafini & Zagato)	—	—	—	—	—	93·6	89·3	92·3	76·3	78·7
White bread, minced meat, eggs, butter, sugar, broth, tea (Khlopine)	—	—	—	—	—	97·2	93·3	95·6	99	—
Vegetarianism : Pumpernikel or rye bread with bran, fruits, butter (Vict and Constantinidi)	—	—	—	—	—	90·0	59	70	91	—
Vegetarianism : Black bread made with bran, apples, dates, oatmeal, rice, sugar, nuts (Rumpf and Schumm)	—	—	—	—	—	—	66·1	76·5	—	—
Mixed alimentation of Europeans (Eijkman)	—	—	—	—	—	94·3	88·6	94·4	97	85·4

According to the recent researches of Atwater, the coefficients of intestinal utilization of alimentary principles of different origins are as follows :

Principles.	Utilized for 100 Parts.		
	Albuminoids	Fats.	Carbohydrates.
Borrowed from flesh, eggs, milk . . .	97	95	98
,, ,, cereals	85	90	98
,, ,, dry vegetables	78	90	97
,, ,, herbaceous vegetables . .	83	90	95
,, ,, fruits	85	90	90
,, ,, fecula	—	—	98
,, ,, sugar	—	—	98
Average for animal alimentation . . .	97	95	98
,, ,, vegetable ,, . . .	85	90	97
,, ,, ordinary mixed alimentation .	92	95	97

These researches have shown that white bread is the food which, taken exclusively, is best utilized. It is absorbed to the extent of 96·3 per cent. According to Rübner, a mixed diet of *bread and milk*, in equal parts, is absorbed in the proportion of 93·8 per cent. ; *bread and eggs* of 95·6 per cent. ; a régime of *bread* (2 parts) *meat* (1 part) which forms an average alimentation well responding to the needs of the economy as regards albuminoid and ternary principles, has given to Rübner, as an average alimentary utilization, the proportion of 94·4 per cent. The mean coefficient of mixed alimentation, calculated according to the experiments of Atwater, leads to the coefficient of ultilization of 95·5, that is to say, for a good average alimentation, 4·5 per cent. only of the whole of the organic alimentary products, calculated dry, remain unused in the intestine.

The complete diet of *milk, meat, bread, butter ;* or *meat, bread, rice, cheese, butter, beer ;* or *meat, potatoes, gruel, peas, butter, cheese,* which corresponds very nearly to the customary diet of the workman, gives a total utilization varying from 95 per cent. (in the first case) to 87 per cent. (in the last case).

We should remember once more that in virtue of some intestinal secretions, one reckons as unassimilated nitrogen, the nitrogen rejected with the intestinal mucus. These figures, and particularly those which relate to the albuminoids, are minimums.

If the vegetable elements predominate in the alimentation, the total utilization diminishes : 14 to 18 per cent. of the utilizable alimentary material is then found in the fæces. They are accompanied besides by the ligneous and cellulosic portion abundant in these cases and almost inutilizable.

Herbaceous vegetables leave then marked excretory residues, because their cellulose is not digested in the human intestine or only with very great difficulty ; because they also introduce some starchy or mucilaginous substances, often difficult to transform into sugar ; lastly, because their proteid materials have not time to undergo, at any rate in the case of man, in the course of

a too short intestinal passage, the digestive transformations which precede their assimilation.

These investigations of Rübner and those of Atwater show then that the quantum of utilization of equal quantities of albuminoids, of fats or of starches derived from different origins is far from being the same. The intestine makes a very different use of each of them and, in our species in particular, the materials of animal origin are always much better digested and absorbed than those which are furnished to us by plants.

Of all aliments, flesh and fish provide us with the most utilizable albuminoids: 97·5 to 97·3 per cent. of these principles pass through the intestinal wall into the blood. Out of 100 parts of casein furnished by milk, only 95 parts are absorbed. But if we borrow the albuminoids from bread, for every 100 parts of gluten calculated in the dry state, 78·9 pass through the bowel into the chyle; finally, there pass only 80 to 60 parts per cent. if we take the proteids from vegetables proper.

Daily experience entirely confirms the researches of the laboratory: everybody knows that vegetables *do not nourish so well as meat*; moreover, we here see, and in an exact manner, that they do not nourish so well even with an equal weight of albuminoids; in the relation of 85 to 97, or 87·5 (*vegetable foods*) to 100 (*foods of animal origin*). We will return later on to the important applications arising from these observations.

Assimilation of Aliments.

When aliments have been digested, transformed in the intestine into products capable of reabsorption, they have not yet acquired the faculty of nourishing us. As a matter of fact, the proteid substances of the tissues differ not only in different kinds of animals but in each kind of cell of the same animal, and in order to nourish each of these cells the albuminous matter brought by the circulation must undergo in each of them a final digestion. It is the same with fats and different sugars: the glucose and levulose originating from the intestinal digestion of cane sugar both reach the lymphatics, but the levulose disappears or is transformed in transit into glucose, which alone we find in the blood of the Vena Porta. When it has reached the liver, this glucose itself is changed into glycogen, identical with that of the hepatic organ of the animal but sensibly different, as I have shown before, in each species of animal. It is only after it has undergone there many transformations, that we can say that the primitive saccharose has been assimilated.

It is the same as regards albuminoid matter, animal or vegetable, when it has been changed in the intestine into peptones and reabsorbable amido-acids by the villi of the intestines, it is still not suitable for the nourishment of the protoplasms.

While traversing the intestinal membrane, all these products of the digestion of the proteid bodies are again modified by a last ferment, erepsin, and so thoroughly, that in full digestion, we no longer find any trace of the peptones of the intestine in the blood of the mesenteric veins and Vena Porta. But in the blood plasma we do not find either musculin, casein, mucin, ossein, chondromucoid, elastin, nuclein or protagon, etc.; in a word, any of the specific products from which are formed the different tissues which feed the blood. Thus, the mechanism by which each cell nourishes itself and grows, is not a kind of elective attraction, of selection which each tissue would exercise on the nutritive materials indiscriminately dissolved in the heterogeneous milieu which the lymph or the blood enriched by the digestive juices represent (pp. 2 and 4). In reality, each kind of cell, those of muscle, nerve tissue, connective tissue, different glands, bone, cartilage, etc., manufactures different products in its protoplasms, while taking from the blood nutritive elements *which are not those of which it is composed, but which it is able to form by their union among themselves.* Each cell *assimilates*, that is to say transforms into substances identical with its own, different materials brought by the blood. Each one produces the cytoproteids and nucleoproteids, the different fats which are suitable to it, according to the regions and tissues nourished by the same blood.

One perceives then, that the origin of assimilable products has an influence on the rapidity of their definite adaptation to each organ. The vegetable albuminous principles assimilate with more difficulty and less completely than those of animal origin, and there are amongst animal products, specific albuminoid matters which are unassimilable or assimilate with difficulty, viz. those of bone, cartilage, elastic tissue.

It is thus that the coefficients of alimentary utilization of Rübner and Atwater show that one could not without disadvantage replace, weight for weight, the albuminoid of animal origin by those borrowed from vegetables. It is the same with the substitution of starch or sugars for fats in chemically equivalent proportions. Fr. Hoffmann fed a man for several days with 1,000 grms. of potatoes, 207 grms. of lentils and 40 grms. of bread. This ration contained 66 grms. of albuminoids, 18 grms. of fat and 255 grms. of carbo-hydrates. Under these conditions, the subject experimented upon lost 24 per cent. in weight of his ration calculated in the dry state, and 47 per cent. of the total nitrogen. The above ration was replaced by the following, principally animal, and containing nearly the same quantity of assimilable nitrogen and carbon: meat 390 grms., fat 126 grms., bread 40 grms. The subject did not, from this time, lose more than 17 per cent. of absorbed nitrogen, and did better work than in

the first case, although, in the two régimes, the calculated quantity of alimentary energy furnished to the subject during 24 hours was very sensibly the same.

The adaptation of different nutritive substances to the needs of the system commences then in the intestine, continues across its walls and in the lymphatic ganglia of the mesentery, follows on into the liver and terminates in each cell by a specific assimilation. In the digestive tube and its annexes, there takes place only a semi-assimilation. But we should be quite wrong to regard intestinal digestion of food as a simple liquifaction, destined only to allow of its passage into the blood. If this intestinal preliminary work is not accomplished, definite assimilation cannot be carried out. Hence the impossibility, as we shall see further on, of nourishing patients by subcutaneous injections of peptones or derived albumins, etc., because these substances have not undergone the preparatory transformations which the ferments of the intestine and mesenteric ganglia imprint on them. Soluble albumins, such as the white of egg, peptones, gelatin, not modified by intra-testinal digestion, if they are injected under the skin, pass rapidly into the urine. However soluble, these substances remain inassimilable when they are introduced by this direct way, and are often even poisonous.

VI

EXPENDITURE OF ENERGY IN THE CASE OF A MAN AT REST—PRINCIPLES RELATING TO THE REALIZATION OF THE ENERGY FURNISHED BY FOODS—VALUE IN ENERGY OF THE ALIMENTARY RATION

IF, during a given period, a healthy adult animal varies neither in condition nor in weight, we may say that the virtual energy of the aliments which he absorbs, in twenty-four hours for example, is entirely employed in compensating for the losses occasioned by heat, work, etc., which have been induced by the activity of the organism. It is true that hydration, combustion, decompositions, etc., which provide him with the necessary energy are produced especially by the consumption of materials already assimilated and stored in his organs. But these materials being immediately replaced by the principles which alimentation continually provides, we can say that, in a healthy organism, which rests in equilibrium of weight, general composition and condition, all the energy expended corresponds to that which the aliments have introduced during the period under consideration. Thus the alimentary needs, in the case of a normal adult man, will be proportional to the expenditure of energy of which he is the centre; and such is the principle of a new method which in its turn will give us the measure of these needs, a method differing entirely from those which are based upon the statistics of general consumption by large human communities, or on the methodical and precise observation of certain particular cases, or on that of the nutritive balance.

It is also necessary to ask oneself what are the needs and losses of energy of the man whose organs function normally, how to measure these needs, and how they can vary according to this same activity.

Let us try to determine the amount of energy expended by the living organism.

This expenditure, if the animal is healthy and does not vary in weight and state, consists in losses of heat, the production of work, and phenomena of a nervous or psychic order.

We mention these latter, since they constitute a form of vital activity; but they cannot, in reality, correspond to an expendi-

ture of sensible material energy. An impression strikes our senses, it runs through the special nerve which has received it and which carries it to the nerve cells, where this impression is transformed, preserved, perceived or not, by the psychic centres. This impression acts then materially on the ganglionic or upon the central nerve cells, but it can only have for material equivalent the labour that is represented by the energy causing the impression. Now, the one thousand-millionth part of a gramme of an odoriferous substance like musk, or a quantity of light scarcely capable of affecting a millionth of a milligramme of silver salts, or the inappreciable energy contained in the sound waves which speech transmits to us, suffice to call into play our olfactory, visual or auditory organs. The transformations undergone by the nerve centres, through the action of outside agencies, are very real, but of inappreciable magnitude, equivalent as they are to a quantity of energy which is nearly insensible, comparable indeed in magnitude to that conveyed by the feeble light which acts on a very sensitive photographic paper in the millionth part of a second. It is true that the nervous action thus provoked can secondarily put in action such or such functional organs, excite or inhibit their activity, their circulation, the secretion of their ferments, etc., and thus produce some definite effects corresponding to an expenditure of energy superior to that which started it. But all these intermediate nervous phenomena of whatever nature, demonstrating themselves through *interior labours*, which follow and balance one another, *disappear mathematically* in the calculation of the definite expenditure of energy, when the individual has returned to his primitive material state.

But if, after the series of these passing transformations, the subject has changed neither in weight nor in chemical or physical constitution (the insensible material modification nearly corresponding to the psychic or chemical act of the impression), the expenditure of energy relative to the cycle of operations under consideration will always be measured by the loss of heat or the production of *exterior work* on the part of the subject under experiment.

In a word, the intermediate interior states do not play any part in the calculation of the expenditure of this energy.

Thus, psychic phenomena may appear after the functional modifications which have originated them, and the energy which has successively caused them, have disappeared. These psychic acts, therefore, could not be equivalent to any part of this preparatory work of receiving and registering impressions. *After the material phenomena have been produced, the aptitude to revive these impressions by the mind, to compare them with preceding impressions and to judge their relations of analogy or causality,*

a comparison which constitutes the act of thought itself, all these acts, more or less sensible to our consciousness, are not equivalent to any expenditure of energy, because *feeling, comparing and willing is not acting*, also the material act, transforming itself by some modifications, material or even transient, alone corresponds to an equivalent expenditure of energy.

In the case of a healthy adult, the daily alimentary needs are only equivalent to the exterior losses by means of heat and mechanical work. Now, it is possible to calculate the energy relative to these two sorts of expenditure. According to direct observations made by M. d'Arsonval with his anémo-calorimeter, a man weighing 74 kgs. seated and clothed, one hour after food and at a temperature of 18°, lost 69·6 Calories. MM. Bergonié and Ségalas give the following figures for two men weighing respectively 72·750 kgs. and 70 kgs. :

Surrounding Temperature.	Calories Lost per Hour.	
	Man weighing 72·750 kgs.	Man weighing 70 kgs.
12° C.	69·5	57·78
14° C.	68·5	79
15·5° C.	56·5	68·5

Taking the mean of these numbers and bringing them to 15° and to 65 kgs. (the average weight of an adult), it is found that the expenditure of heat in the case of a man clothed, at rest and in a temperate climate, works out at about 64 Calories per hour, or 1,536 Calories per 24 hours. To these figures the following items should be added : 1st, that amount of heat which becomes latent by the transformation into vapour of 1,200 cc. of water, whether thrown off by the skin or the lungs ; let us put this at 1·050 kg. × 582 = 611 Calories.[1]

In the calculation on the following page these figures should be reduced by that amount of heat which has already been registered by the calorimeter when this vapour is cooled from 38° to the surrounding temperature.

2nd, the amount of heat necessary to raise the temperature of the air which enters the lungs cold but issues from them warmed —roughly 80 Calories. 3rd, the amount of heat necessary to raise the temperature from 14° to 38° both of that part of the diet

[1] The quantity Q of heat necessary to convert 1 kg. of water into the state of vapour at the same temperature has been found by V. Regnault to be :

$Q = (606{\cdot}5 - 0{\cdot}695\ t)$ Calories ; about 581·8 Calories when $t = 38$ °.

which is received cold into the system, as well as the daily allowance of drinking water. This may be estimated at about 53 Calories. 4th, the quantity of heat expended under the form of work, by the respiration muscles—about 50 Calories (calculating the mechanical energy in Calories). 5th, the amount of heat which corresponds to the movements, the insignificant changes and involuntary actions of a man at rest which may be estimated at 150 Calories. By adding all these numbers together we shall have the total expenditure in Calories, either lost directly or corresponding to the slight expenditure in the form of work, of an average man at rest. The following table gives the result of such a calculation :

	Calories
Radiation from the body of an average man . . clothed	1,536
Latent heat due to the evaporation of about 1,100 grms. of water by the skin and lungs	611
Heating of the expired air	80
Heating of the aliments and drinking water taken cold and raised to the temperature of the body : heat lost by the urine and fæces : total	53
Work performed by the heart and respiratory muscles. Other interior and minor exterior actions necessary to the maintenance of the activity of the organism[1]	150
Total expenditure (expressed in Calories) . .	2,430

Such is approximately the total daily expenditure, expressed in Calories, of the average adult, living at ease, in a temperate climate.

Principles relating to the realization of energy supplied by food. Does our daily diet supply us with a quantity of free energy corresponding to this average waste ? Does it furnish us with a different quantity of energy if we have to perform mechanical work ? In the second case, what part of the alimentary energy is transformable into work ?

Before discussing these questions it will be well to remember that if an individual in health who does not vary in weight, receives a given quantity of food and, after deriving nourishment from it, converts it into solid, liquid or gaseous excreta, he will benefit by a fixed amount of energy provided always that the

[1] The work of the heart and of the respiratory muscles, if estimated separately, would alone greatly exceed 50 Calories, but it must be remembered that the greater part of this work is expressed in the form of friction—of the blood in the vessels, of the respiratory muscles, etc., and the amount of work which is thus changed into heat is included and expressed in the Calories radiated by the skin. Finally, the last item, 150 Calories, which gives the amount of heat corresponding to involuntary and indeterminate actions, is subject to considerable variations to the behaviour of the subject in a state of *relative* repose.

initial states—*the body and food*—and the final states—*body and excreta*—are the same, *whatever the nature of the intermediate states* may have been. This rule applies to all the cases which come under observation. Whether a certain quantity of sugar, 10 grms. for instance, be burnt in a calorimeter slowly or quickly, or whether given to some animal to be utilized by it for its nourishment, if this sugar is entirely rejected by this animal, as if out of the calorimeter, in the state of water and carbonic acid, provided that the living creature remains materially as it was before being fed with this substance, these 10 grms. of sugar in changing into water and carbonic acid will have always set free a quantity of heat (39·6 Calories) identical with that which can be measured by its combustion in the calorimeter, and this is so whatever the intermediate states through which the animal and the sugar have passed.

Sometimes a food, after passing through the human economy, is converted into waste matters which are only partially oxidized and still capable of combustion if brought to a red heat, by the agency of an increased amount of oxygen. In such cases, the heat produced (by oxidation or otherwise) by the combustion of this partially consumed food, is equal to that which would have resulted if it had been entirely burnt in the calorimeter, deducting the heat produced by the total combustion of all the residuary products still combustible into which the food-stuff is definitely transformed.

For example, if 10 grms. of albumin are completely transformed by the organism (whilst absorbing 17 grms. of oxygen) into water, carbonic acid and 2·8 grms. of urea, whatever may have been the various intermediate states of the organs in which this transformation took place, these 10 grms. of albumin, in being so destroyed, will put 48·57 Calories at the disposal of the animal; that is to say, the quantity of heat which these 10 grms. of albumin would produce by their rapid and complete combustion in the calorimeter, less the number of Calories corresponding to the total combustion of 2·8 grms. of urea, that being the only residue of these 10 grms. of absorbed and transformed albumin which is still capable of combustion. And if, as is usually the case, it only produces 84 to 85 hundredths of the theoretical quantity of urea (in this case 2·38 grms., 15 per cent. of albumin having yielded nitrogenous bodies other than urea), it will be necessary in calculating the quantity of real heat produced, to subtract from the Calories furnished by the total combustion of 10 grms. of albumin, the quantities which the combustion of 2·38 grms. of urea and of the other nitrogenous bodies formed at the same time would give.

If, during the period of alimentation which is under consideration, the animal has performed any external work, the heat radiated

by it or rendered latent during this period, is equal to the heat produced by the chemical changes of the intermediate principles of its aliments, diminished by the heat equivalent to the exterior labour performed by the animal; that is to say, one Calorie disappears for every 425 kilogrammetres produced.

The result of these calculations, as M. Berthelot has already stated, is that: "*The maintenance of life does not consume any part of the energy belonging to it, and that the nature of the intermediary transformations, through which the animal passes, does not play any part in the calculation of the energy necessary to its maintenance, provided that the initial and final states of the living being remain the same.*" [1]

These preliminaries being established, we can now calculate the quantity of total energy which the average alimentary allowance (determined experimentally as described above) puts at our disposal, provided that we know at the same time not only the composition of these aliments in assimilable and combustible principles, but the nature of the final transformations of these principles in the economy; and lastly, the heat given by the combustion of each of these principles and of their residues. In order to calculate the energy which corresponds to the actual destruction of these matters, we must estimate: 1st, not the proportions which are introduced into the system by means of food, but rather *the quantities which are re-absorbed and which traverse the intestinal walls.* 2nd, the forms under which the alimentary residues are rejected by the economy. But before attacking the whole of the problem from the practical side, I think it would be useful to give in the following tables the quantities of heat produced: 1st, by *the total combustion in the calorimeter* of the most important organic alimentary principles; 2nd, by the total combustion of the albuminoids, minus that of the quantity of urea which theoretically corresponds to them.

The figures in these tables give the measurements of the quantities of heat which correspond, in each case, to the combustion of each alimentary principle, admitting that the combustion is complete.

In the case of the albuminoids, these figures give in one column the amount of heat produced by their complete combustion; and in the other, the amount of heat produced if we assume that their entire quantity of nitrogen passes finally into the form of urea.

[1] M. Berthelot, *Essai de mécanique chimique*, t. I, p. 91.

A. Calories Produced by the Total Combustion, in the Calorimeter, of Different Alimentary Non-nitrogenous Principles.

Name of Substance.	Formula.	Heat of Combustion in Calories for 1 grm. of Matter.	Quantity of Material giving 1 Calorie.
			grms.
Alcohol vinic . . .	C^2H^6O	7·061	0·1417
„ butylic . . .	$C^4H^{10}O$	8·55	—
„ amylic . . .	$C^5H^{12}O$	9·96	—
Glycol	$C^2H^6O^2$	4·564	—
Glycerine	$C^3H^8O^3$	4·317	0·2347
Mannite	$C^6H^{14}O^6$	4·003	—
Glucose and its isomerics	$C^6H^{12}O^6$	3·739	0·2674
Inosite	$C^6H^{12}O^6$	3·702	—
Arabinose	$C^5H^{10}O^5$	3·726	—
Starch	$(C^6H^{10}O^5)^m$	4·227	0·2364
Inuline	$(C^6H^{10}O^5)^m$	4·184	0·2390
Dextrine	$(C^6H^{10}O^5)^p$	4·180	0·2429
Cellulose	$(C^6H^{10}O^5)^q$	4·209	0·2376
Saccharose	$C^{12}H^{22}O^{11}$	3·962	0·2524
Lactose	$C^{12}H^{22}O^{11}$	3·777	0·2648
Acetic acid . . .	$C^2H^4O^2$	3·505	0·2853
Butyric „ . . .	$C^4H^8O^2$	5·912	—
Valeric „ . . .	$C^5H^{10}O^2$	6·608	—
Caproic „ . . .	$C^6H^{12}O^2$	7·164	0·10795
Margaric „ . . .	$C^{16}H^{32}O^2$	9·262	0·10601
Stearic „ . . .	$C^{18}H^{36}O^2$	9·433	0·10515
Oleic „ . . .	$C^{18}H^{34}O^2$	9·510	—
Oxalic „ . . .	$C^2H^2O^4$	0·667	—
Succinic „ . . .	$C^4H^6O^4$	3·000	0·2731
Lactic „ . . .	$C^3H^6O^3$	3·661	—
Citric „ . . .	$C^6H^6O^7$	2·500	0·4000
Malic „ . . .	$C^4H^8O^3$	4·549	0·2198
Benzoic „ . . .	$C^7H^6O^2$	6·319	—
Quinic „ . . .	$C^7H^{12}O^6$	4·389	—
Trilaurine	$C^{57}H^{104}O^6$	8·945	0·10140
Triolein		9·862	
Tristearine	$C^{57}H^{110}O^6$	9·840	0·10163
Pork fat	—	9·380	0·1066
Mutton fat	—	9·406	0·1063
Butter	—	9·192	0·1088
Olive oil	—	9·328	0·1072

B. Calories Produced by the Principal Alimentary Nitrogenous Substances: 1. From their Total Combustion in the Calorimeter; 2. In the Case where Urea is produced.

Name of Substance.	Formula.	Heat produced by the total combustion in the Calorimeter of 1 grm. of substance.	Heat calculated for the transformation into H^2O, CO^2 and urea of 1 gram. of matter.
Oxamide	$C^2H^4N^2O^2$	3·250	—
Alanin	$C^3H^7N^2O^2$	4·370	3·562
Asparagin	$C^4H^8N^2O^3$	3·395	2·306
Hippuric acid	$C^9H^9NO^3$	5·659	5·490
Urea	CH^4N^2O	2·690	0·00
Tyrosin	$C^9H^{11}NO^3$	5·918	5·203
Taurin	$C^2H^7NSO^2$	2·503	0·000
Leucin	$C^6H^{13}HO^2$	6·526	6·191
Uric acid	$C^5H^4N^4O^3$	2·747	1·040

C. Calories Produced: 1. By the Total Combustion of the Substance. 2. Allowing that the entire Quantity of Nitrogen is Eliminated in the form of Urea.

Name of Substance.	Heat produced by the total combustion in the Calorimeter of 1 grm. of matter.	Heat produced by combustion of 1 gram of matter assuming the formation of urea.	Quantity of matter giving 1 Calorie in the production of urea.
			grms.
Egg albumin	5·687	4·857	0·2059
Blood fibrin	5·529	4·749	0·2104
Haemoglobin	5·914	4·964	0·2015
Casein	5·629	4·820	0·2075
Ossein	5·414	4·546	0·2209
Isinglass	5·242	—	—
Viteline	5·784	4·954	0·2018
Gluten	5·994	5·245	0·1906
Chitine	4·655	4·235	0·2361
Yolk of dry egg [1]	8·124	7·704	0·1298

[1] The following figures taken from Danilewsky, give the number of Calories obtained by the total combustion of different edible materials and per gramme of dry substance.

Wheat flour	4·47	Rice	4·81
Beef without fat	5·43	Rye bread	4·47
Flesh of frog	5·53	Lentils	4·89
Ox Blood	5·90	Maize	5·19
Cow's milk (calculated dry)	5·73	Brain	7·14
Human Milk	4·23	Oats (whole)	5·10
Potatoes	4·84	Cabbage	4·12
White bread	4·35	Hay	4·35

All Danilewsky's figures are only approximate.

A litre of cow's milk corresponds to about 750 Calories. With the addition of 60 grms. of sugar it represents about 1,000 Calories.

Coefficients of Real Utilization of the Alimentary Principles.

It is now possible for us to calculate, by means of the three methods already described, at least theoretically, in the form of Calories, the energy contained in the alimentary allowance for twenty-four hours. We have found that the daily nourishment of an adult at rest ought to contain an average of 107 grms. of albuminoids, 64·5 grms. of fats and 407 of carbo-hydrates (see p. 24). According to the table below, if these principles were strictly absorbed in the intestine, then transformed into water, carbonic acid and urea, in traversing the system, they would theoretically give the following figures :

Weight in Dry State.		Calories Produced.
Albuminoids .	107 grms.	107 grms. × 4·8 = 514
Fats . . .	64·5 „	64·5 „ × 9·8 = 632
Carbo-hydrates .	407·5 „	407·5 „ × 4·22 = 1720
		Total . . 2866

But we have seen that Rübner, and later Atwater, have established the fact that in an average normal case, a proportion (5 to 5·5 per cent. according to Rübner, while Atwater gives 4·5 per cent.) of the nourishment remains unutilized by the organism and passes into the fæces. The number of Calories therefore corresponding to the average ration should then be diminished by about 5 per cent., that is to say 145 Calories.

This is not all; as we have already said, the proteid matters, fats and sugars, which penetrate into the economy, are not entirely transformed after intestinal absorption, the albumin into water, carbonic acid and urea, the fats and sugars into water and carbonic acid. A part of these substances changes itself into products of excretion which are only partially oxygenized, hence the production of a smaller amount of heat. Thus, of 100 parts of albumin received by the normal healthy organism, the maximum quantity which decomposes to form urea is from 83 to 90 parts per cent., while from 10 to 17 per cent. are converted into other nitrogenous substances (uric and hippuric acid, xanthic bodies, extractive substances, colouring matters, etc.). In the same way, besides water and carbonic acid, the sugars and fats produce small quantities of acids—oxalic, succinic, lactic, benzoic, etc., which reappear in the different excretions. Thus, the energetic coefficient or actual or practical calorific is always lower than the theoretical coefficient. This practical coefficient has been established in two ways : 1st, by means of analysis of the excreta and the calculation of their residuary caloric energy, which must be deducted from the energy corresponding to the destruction of the entire amount of food under consideration.

2nd, experimentally and directly by collecting and measuring the heat produced in each case. We give here Rübner's and Atwater's coefficients to which, for the sake of comparison, we add the theoretical coefficients.

1 grm. of assimilated matter yields in decomposition

	Theoretically.	In the Economy	
		Rübner.	Atwater.
Animal albumin (with formation of urea)	4·85	4·2 cal.	4·25 grms.
Vegetable albumin (gluten, etc.)	5·24	4·1 ,,	3·55 ,,
Animal fat	9·40	9·3 ,,	8·95 ,,
Vegetable fat (olive oil)	9·32	9·0 ,,	8·35 ,,
Sugar (glucose)	3·74	4·0 ,,	4·00 ,,
Starchy matters	4·23	4·1 ,,	3·60 ,,

Such are, on an average, the quantities of real energy, counted in Calories, which each of the alimentary principles yields for each gramme of matter which, after having penetrated into the lymphatics and the blood, is eventually split up and destroyed in our organs.

But Rübner had already recognized what Atwater afterwards confirmed, that the transformations into energy of the various proteid principles (fats, starches, sugars) varies sensibly according to the nature of the aliment from which they proceed and of the régime with which they are associated. By means of a long series of experiments with his respiratory calorimetric room Atwater, as will be shown later, has fixed the coefficients of energy resulting from these régimes, as follows :

Calories, According to Atwater, Produced by Destruction in the Economy of 1 gramme of the Different Fundamental Alimentary Principles.

Origin.	Calories for 1 grm. of proteids disintegrated in the economy.	Calories for 1 grm. of fat destroyed in the tissues.	Calories for 1 grm. of disintegrated carbohydrates.	Proportion per cent. of the actual available energy derived from the foods.
Flesh of mammals and fish	4·25	9·00	—	87
Eggs	4·35	9·00	—	89
Milk and derivatives	4·25	8·80	3·80	93
Average of animal food	**4·25**	**8·95**	**3·80**	**89**
Bread and cereals	3·70	8·35	4·10	91
Vegetables in grain	3·20	8·35	4·05	83
Green vegetables	2·90	8·35	3·85	98
Fruits	3·15	8·35	4·10	98
Sugar	—	—	4·00	91
Starch	—	—	3·60	88
Average of vegetable food	**3·55**	**8·35**	**4·00**	**02**
Average of mixed food	**4·00**	**8·90**	**4·00**	**91**

Thus, one gramme of albumin split up in the economy and converted principally into urea, water and carbonic acid will yield, not 4·86 Calories, but 4·25 Calories, if it is derived from meat, and only 3·70 Calories if derived from bread. As a result of combustion in our organs 1 grm. of animal fat will give not 9·3 Calories, but 9·0 Calories, and only 8·35 Calories will be yielded by vegetable substances. Atwater's table also shows that the following figures will result from the employment of a general mixed diet :

For 1 grm. of disintegrated	albuminoids . .	4·00	Calories
,, 1 grm ,,	fats . . .	8·90	,,
,, 1 grm. ,,	carbohydrates . .	4·00	,,

Finally, the last column of the table gives the *practical alimentary coefficients.* It indicates, for 100 parts of energy virtually contained in each of the nutritive principles which we have considered, the proportion which according to the nature of the aliment, is utilizable, giving an account on the one hand of the loss undergone by the intestinal non-utilization of a fraction of these principles, and on the other of the coefficients of energy produced by each of them according to their origin, after decomposition in the economy. This last column shows, for example, that of 100 Calories corresponding theoretically to one part of albumin derived from meat, if entirely absorbed in the intestine, and transformed into water, carbonic acid and urea—of these 100 Calories only 87 can really be utilized by man. It shows that on an average we realize 89 per cent. of the energy of our animal foods, 92 per cent. of that of vegetable origin and 91 per cent. of the total energy supplied by an average diet.

We know that, for a mixed régime, the intestinal utilization of each principle is therefore as follows :

For 1 gramme.	Absorbed in the Intestine.	Retained in the Fæces.
Albuminoids	0·92 grms.	0·08 grms.
Fats	0·95 ,,	0·05 ,,
Carbo-hydrates	0·97 ,,	0·03 ,,

The *really utilizable* quantities of energy derived from a mixed diet and expressed in Calories, are therefore as follows:

Mixed Diet.	Mean co-efficient of intestinal absorption.	Calories per grm. after decomposition.	Calories per grm. contained in the food.
For 1 grm. of albumin . .	0·92	4·00 cals.	3·68 cals.
,, 1 grm. of fats	0·95	8·90 ,,	8·65 ,,
,, 1 grm. of carbo-hydrates .	0·97	4·00 ,,	3·88 ,,

Such are the *practical multipliers* which, in the case of a mixed diet, allow us to calculate the utilizable energy of each ration, if we know the composition of the aliments and the quantity of each which is daily consumed.

We see that as a rule, either by incomplete intestinal absorption, or by imperfect combustion in the organs, the economy loses nearly a tenth of the theoretical energy which would be at its disposal if the total amount of the alimentary products were reduced by combustion, to water, carbonic acid and urea.

Applying these ideas to the average normal régime of an adult at rest, such as already described (p. 24), we shall have :

	Quantities per 24 hours multiplied by Atwater's Coefficients.	Corresponding Calories.
Albuminoids . . .	107·3 grms. × 3·68	394·8 cals.
Fats	64·5 „ × 8·65	557·9 „
Carbo-hydrates . . .	407·5 „ × 3·88	1581·1 „
	Energy expressed in Calories per 24 hours	2533·8 cals.

Expressed in Calories, such would be definitely the true value of the energy supplied by an average diet to a man in a normal, healthy condition.

In illustration of this point some results anterior to ours, but calculated with Rübner's coefficients, here follow :

	Energy supplied by the Daily Diet (in Cals.)	Authors.
Doctors, clerks, etc., ration of maintenance	2631 Cals.	Rübner.
English citizen	2641 „	Forster.
German workman at rest . . .	2859 „	Pettenkoffer and Voit.

These numbers, and particularly the last, have been since recognized as too high. They should be reduced by about a twentieth. We ourselves, in calculating the energy expended by an adult in a state of repose (p. 53), found the figures 3,459 Calories per 24 hours too high.

The number deduced from the average dietary in Paris is 2416 Calories.[1]

[1] The calculation according to the data on p. 18 is as follows :—

Albuminoids	102 grms.	× 3·68 Cals.	=	375·4 Cals.
Fats	56·5 „	× 8·65 „	=	488·7 „
Carbo-hydrates . . .	400 „	× 3·88 „	=	1552·0 „
		Total		2,416 Cals.

All these values agree.

Working from Atwater's coefficients as the best, we find that in the case of a normal man weighing 65 kilos. and in a state of comparative repose, the utilizable energy derived from a normal diet increases to about 39 Calories per kg. of body weight.

Here we speak only of the régime of maintenance or of relative repose. In a state of complete repose in bed, the number of necessary Calories falls on an average to 31 Calories net according to Ranke, and even to 24 Calories according to Tigerstedt,[1] per kg. of body weight per 24 hours.

These numbers are applicable to the average adult man, but they vary considerably according to age. The following numbers have been *calculated* by Rübner[2] for children, young people and full grown men.

	Body weight.	Total waste calculated in Calories per 24 hrs.	Calories per kilogramme of body weight.
Children of . .	4·030 kgs.	368 Cals.	91·3 Cals.
" . .	11·800 "	966 "	81·5 "
" . .	16·400 "	1213 "	73·9 "
" . .	23·700 "	1411 "	59·3 "
Young men . .	40·400 "	2106 "	52·1 "
Men	67·000 "	2843 "	42·4[3] "

We shall see in Part III, à propos of the variations of régimes with age and size, that the alimentary needs of the economy are above all regulated by the temperature of the body, and depend on the surface of the subjects far more than on their weight.

[1] *Calories net*, that is practically disposable.

[2] *Zeitsch. f. Biolog.*, t. XXI, p. 396.

[3] All these numbers are certainly too high by about a tenth to a twentieth.

VII

EXPERIMENTAL CALORIMETRY IN A LIVING AND FUNCTIONING MAN—ATWATER'S RESPIRATORY CHAMBER—RESULTS OBTAINED

THE method of determining the average quantity of aliments necessary to the functioning of a man at relative ease, that is to say only doing work indispensable to his maintenance, has been set forth in the preceding chapters; 1st, by calculating the weight of his average food and the elements which compose it, and multiplying their weight by the coefficient of calorific utilization of each of them; 2nd, by estimating the deficiencies which have been caused by the expenditure of a given amount of energy; by the heat lost by radiation, convection, pulmonary or cutaneous aqueous evaporation; by the work of the respiratory organs; finally, by the small expenditures (difficult perhaps to appreciate) which correspond exactly to the light and complex work of a man in health, who, though functioning freely, is nevertheless taking only that amount of exercise which is indispensable to his existence (see p. 53).

It is possible to-day, thanks more especially to the important works of W. O. Atwater, the learned director of the *Experimental Station of Alimentation of the United States Agricultural Department*, not only to calculate, but *to measure exactly* in the form of heat, the losses of energy (cooling, cutaneous and respiratory evaporation, mechanical work, etc.) of animals, of man in particular, living, functioning and working, and to compare in each case, with the energy thus gathered, the energy furnished by the foods.

Better than all those which have preceded them, the splendid researches we are about to analyze have shown:[1]

1st. The measurement of the amount of energy expended by the man in health and the relative proportions of this energy appearing under the form of lost caloric and of work produced.

2nd. The exact determination of the coefficients of energy yielded by each alimentary principle (see preceding chapter)

[1] Published by Atwater and his collaborators from 1898 up to to-day, by the U.S. *Dept. of Agriculture*; in the *Annual Report of the Office of Experiment Stations, Washington.*

and the variations of these coefficients according to the dietetic régime.

3rd. The solution of the following problems :

a. Whether the amount of alimentary energy or its utilization varies according to the state—whether of repose or of work, mechanical or psychic—of the subject.

b. Whether stimulating or inhibitory substances exist, which have power to augment or diminish the transformation of food into energy, or to modify the coefficients of utilization of each alimentary principle.

c. Whether combustible substances (alcohols, ethers, aromatic bodies, etc.) exist which are able to pass through the system without being consumed in it, and to what extent certain of them may be utilized by the organs.

The experiments of Atwater and his collaborators, with patients confined for several consecutive days in the calorimetric chamber, have further enabled us to measure the quantities both of oxygen consumed and of carbonic acid, water and nitrogen, etc., excreted. It is thus possible to establish, as much from the chemical as from the energetic point of view, the complete balance of nutritive activity.

These delicate problems had already been partly solved by M. Reiset [1] in their relation to the larger farm animals, and by MM. Pettenkoffer and Voit [2] in their relation to man.

Atwater's study, by means of his calorimetric chamber or *respiratory calorimeter,* of the utilization of food stuffs by the human organism, has been attended by results both masterly and precise.

The subject under experiment eats, works and sleeps in the chamber for several days, and lives rationally in an atmosphere constantly renewed and maintained at a fixed temperature whilst the quantities of heat lost, of work accomplished, of oxygen absorbed, of water, carbonic acid and excretory matter lost by him, are collected and registered outside the apparatus.

These data also permit of the following calculations :

a. The slight variations to which the organism is subjected, it having been previously brought as nearly as possible into a state of equilibrium as regards N and C.

b. The energy expended by it in the form of heat, either radiated or latent, and of mechanical work.

c. The influence which the substitution of one dietary for another and of one combustible principle for another, exercises upon the organism.

Atwater's *respiratory chamber* AA (Fig. 1) and D (Fig. 2)

[1] *Chemical researches on the respiration of farm animals. Ann. Chim. Phys.* (3), t. LXIX, p. 129.

[2] *Ann. Chem. Pharm.*, t. CXLI, p. 295 ; *Sitzungsber. d. bayerischen Akad. d. Wissenschaft,* 1867, t. I ; *Zeitsch. f. Chem.* (2) t. III. p. 30.

(pp. 65 and 66) is formed by five concentric compartments, the two inner ones being constructed of metal, the three outer ones of wood. The innermost chamber is of red polished copper. It is connected by wooden crossbeams with the second casing which is formed of zinc. There is a space of 76 mm. between the two metallic walls. In this space and very near to the inner partition, are placed the weldings of 304 thermo-electric couples intended to convey to the outside, and there register, the exact temperature of the calorimetric chamber.

Besides the patient, this room contains a table, chair, bed, and a fixed bicycle. Its temperature remains constant to nearly one hundredth part of a degree, owing first to the fact that the air before reaching the interior has to circulate between the five coverings, and secondly, to the regulation of the heat produced in the interior, by means of a current of cold water which is manipulated from the outside. The respiratory air is brought there dry and at the same temperature as that of the interior of the calorimeter and the volume of this air is exactly measured as we shall see further on.

The food excretions and products of respiration and perspiration of the subject under consideration are all analyzed both on entering and on leaving the apparatus. The carbon, hydrogen, sulphur, phosphorus, chlorine and metals are estimated.

On leaving, the amount of oxygen which has disappeared from the circulating air, the amount of CO_2, of nitrogen which has appeared (if necessary), and the total amount of water vapour whether excreted by the skin or by the lungs in the respiratory chambers, are all carefully computed.

By comparing the increase or decrease in the quantities of carbon and nitrogen in the excreta with the amount of the same elements introduced by food (which has been previously analyzed), it is possible to calculate, according to the rules already given, the gain or loss of the patient in albuminoids and fats ; the gains being deducted from, or the losses added to, the original alimentary total of these same elements.

It is also possible, as will be seen later, to measure the quantity of heat given off by the patient in the course of the experiment. To this may be added the amount of heat represented by the excretion of water vapour, whether by the skin or lungs of the patient, the water being collected outside the apparatus. Thus the total loss of energy in the form of heat may be ascertained. A fixed bicycle with an ergometer attached to it registers the amount of work performed. The axle of the apparatus is attached to a dynamo, by means of which all the work thus produced is transformed into an electric current, which is, in its turn, changed into equivalent heat in passing through an incandescent lamp placed in the respiratory chamber. The energy

FIG. 1.—PERSPECTIVE VIEW OF THE ENTIRE LABORATORY AND ATWATER'S RESPIRATORY APPARATUS.—*A.A.* Respiratory chamber or Calorimeter; *D.N.* Trough for cooling the air which enters into the chamber, and that which leaves it and deposits its humidity in the metallic condenser, plunged into *N.*; *E.* For measuring the calorimetric water which goes out of the respiratory chamber; *M.* Table for the observer where the temperatures of the chamber are written down; *B.* Port-hole through which the food is passed in and the excretions of the subject taken out; *G.* A door of the calorimetric chamber, partly glazed; *H.J.* Tubes for the circulation of the air which penetrates or leaves the chamber.

[To face p. 64.

lost in the form of radiated heat or of work produced by the subject, is thus completely transformed into heat which may be measured by the temperature of the water which comes out of the apparatus.

The two figures 1 and 2 (p. 66) show, the first in perspective, the second, in horizontal projection, the whole of the installation of Atwater's calorimetric apparatus. In the middle AA (Fig. 1), D (Fig. 2), is the respiratory chamber with its five casings.

This chamber is 2·15 m. long by 1·22 m. broad and 1·92 m. high. It is entered by the door FG (Fig. 1). During the whole of the experiment this door, which has double walls, is hermetically sealed. It is through the porthole B, fastened inside and out (the latter well protected by a non-conducting mattress) that the patient passes out his excreta, liquid or solid, or receives what he requires. Between each of the five casings of the respiratory chamber AA there is a space where the air which passes regularly from one to the other at a temperature equal to that of the interior of the room, circulates as we shall explain farther on. On the left are the air pump E (Fig. 2) and the electric motor F. In front of the respiratory room, a little to the left, is the observer's table CC (Fig. 1), with the galvanometer where the thermo-electric wires wind themselves and register the temperature of the interior of the chamber. In front of the latter, the cooling trough containing chloride of calcium N, the use of which will be seen later. On the right the pump E (Fig. 1), L (Fig. 2), which serves to measure the calorimetric water which issues from the respiratory room. In N (Fig. 2) are three receivers which imprison a one-fiftieth part of the air leaving the chamber in order that it may be submitted to analysis. P_4 (Fig. 2) is the outlet for the air from the refrigerator D going to the meter E (Fig. 1).

The respiratory chamber AA (Fig. 1) is lighted by a double glass pane sealed into the partition and by the double glass door GF.

To the right (near the door) is the measure for the water which penetrates into the chamber by a special tube and which leaves it at a temperature scarcely greater than that of the respiratory chamber, after having carried off the surplus of heat produced by the functioning of the subject. The temperature of this water is ascertained, at very close intervals, to nearly the one-hundredth of a degree, by means of mercurial thermometers placed into the tubes of entry and exit in which it circulates. In entering the apparatus, this water runs through a metallic tube furnished with small wings placed against the internal partition of the calorimeter which it cools by carrying away the excess of heat produced by the patient. This water may be made to flow more or less quickly, and thus the internal

temperature of the room is kept constant. The temperature, as already shown, is ascertained by means of a series of 304 thermo-electric couples, with iron-silver joints, which are placed in the first space around the innermost metallic partition of the chamber, and are almost in contact with it. The thermo-electric wires then meet and are connected with a galvanometer or bolometer placed on the table CC of the observer, where the temperatures of the interior of the apparatus are recorded. It may be regulated to the one-hundredth part of a degree almost, by allowing more or less water to pass into the refrigerating tube. From the measurements of the volume of this

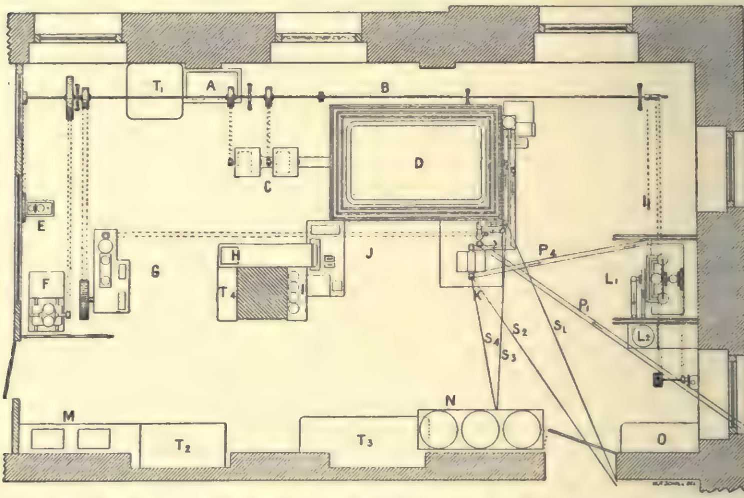


FIG. 2.—PLAN IN PROJECTION OF ATWATER'S COMPLETE APPARATUS FOR MEASURING NUTRITIVE CHANGES. *AC*. Aspiration; *D*. Respiratory chamber; *E*. Air pumps; *G*. Ammoniacal refrigerator; *K*. Cooler of the in-coming air; *L*. Pump for circulating and measuring the water; *M*. Dryers; *N*. Three air exhausters; P_1. Entrance for the air; P_4. Exit of the air from the respiratory chamber.

water by means of the pump E (Fig. 1) and of the excess of its temperature on leaving the calorimeter, the quantity of heat produced may be easily calculated.

The air which penetrates into the calorimetric room should carry with it neither heat nor humidity. Therefore the air drawn in from outside circulates at first in a metallic copper conductor which is immersed in the refrigerating bath ND (Fig. 1) of chloride of calcium maintained at —19 ° C. or —20 ° C. by the ebullition of liquid ammonia. In circulating through the metallic cylinders plunged into the trough at this low temperature, this air loses at first the greater part of its

moisture which the cold causes it to deposit in the form of hoar-frost. The nearly dry air which issues from the large tubes HH is then reheated to the temperature of the inner room before entering the calorimeter. With this end in view, an incandescent lamp is placed at the entry of the air-ducts after the cooling, by means of which this air may be reheated to the exact temperature of the interior of the respiratory chamber, as indicated by the bolometer. Thus heated and dry, the air passes first into the empty space between the first and second protecting wooden partitions ; it then traverses the space between the second and third ; from there to the fourth ; and finally enters the calorimeter at exactly the same temperature as the room. Thus the atmosphere of the internal chamber is uninfluenced by the passage of air from without. But when it finally issues from the calorimetric chamber the air has become charged with all the watery products of the physiological activity of the patient. It is again conducted to the refrigerator ND by the trough D, where it passes through two copper cylinders, which have been previously carefully weighed. These cylinders are plunged into a chloride of calcium bath at a temperature of $-20\,^{\circ}$C.

The air deposits in these cylinders all the water that it contains with the exception of a very small fraction which may be estimated by analysis, as will be shown. The increase in weight of these copper cylinders gives the weight of the water, formed in the respiratory chamber, carried away by the air issuing from it, and condensed in the cooled cylinders.[1]

Thus deprived of the greater part of its water, the air passes eventually into a pump which sucks it in and measures it. At the same time, a fraction equal to the fiftieth part of its volume is deducted automatically in order to determine by an exact analysis the quantities of oxygen lost, of carbonic acid formed and of water remaining. From time to time similar analyses of the air are made before it is admitted into the calorimetric chamber.

The experiments destined to control the value and accuracy of the results given by this delicate and complicated apparatus were made by burning pure alcohol in the calorimetric chamber. It was found possible to recover 99·9 per cent. of the heat produced by its combustion, the alcohol having been previously measured by means of the *bombe calorimétrique* (7·067 Calories per grm. of pure alcohol). Atwater is convinced that the air issuing from the calorimetric chamber would yield, in the same way, 99·9 per cent.

[1] Naturally, in the calculation of Calories produced in the respiratory chamber, we must add to those which have been collected by the water which circulates there, the quantities of heat which correspond to the vaporization of expired and perspired water collected in the refrigerating copper cylinder of the trough *D*.

of carbon and 100·6 per cent. (theoretic) of the hydrogen burnt in the respiratory room. Finally, out of thirteen experiments yielding, according to a calculation of the calorigenic coefficients, a daily average of 2,727 Calories, it was possible to recover 2,722 Calories—that is to say, the exact quantity to about a two-thousandth part.

As regards numerical results, I will only give here those which Atwater published in 1902. The experiments were made on four people working in his laboratory.[1]

E. O., a Swede, assistant in the laboratory, age 32, weight 70 kilos. ; A. W. S., assistant in physics, age 25, also weighing about 70 kilos. ; O. F. T., chemist, age 24, weighing 60 kilos. ; J. F. S., chemist, Canadian, age 20, weighing 65 kilos. While the subjects under observation were *at rest,* they did nothing but make their beds, pass out their excreta by the aperture B, and take a few notes. The rest of the time was occupied in writing, reading or sleeping. *In the working state,* they worked on a fixed bicycle for about 8 hours, a sufficiently fatiguing form of exercise though not excessively so.

The table on the following page gives a few of the results obtained. (*See the whole of this series of experiments,* p. 70).

These interesting researches are very important from many points of view. They have been repeated, and corroborative results have been obtained by both Atwater and his pupils. They prove primarily by an experimental method that, as M. Berthelot states, *the maintenance of organic life does not rob the organism of any part of its energy.* In the case of patients living, working, sleeping, thinking, in Atwater's calorimetric chamber, the sum of the energy expended daily and registered outside the apparatus is exactly the same as that which would have resulted if these same food-stuffs had been transformed into the same products by combustion or any other process. Measured by the calorimeter, this energy may be stated as 2,727 Calories on an average per twenty-four hours. As we have just seen, it is actually represented by almost identical figures (allowing for a slight experimental error) namely 2,722 Calories.

A man in normal activity expends no energy which is not represented by production of some sort. For instance, muscle is able to transform into labour the latent energy given by food. But this labour, if it is inversely converted into heat, will reproduce the same amount of energy as that which would have resulted if the food had been converted into the same products, labour and heat, by means of the calorimeter or any other agency. No fraction of the chemical energy transformed into labour—which

[1] *Experiments on the Metabolism of Matter and Energy in the Human Body* (1898–1900), by Atwater and Benedict ; Washington, 1902.

TABLE OF GAINS AND LOSSES IN NITROGEN, CARBON AND EXPENDED ENERGY OBSERVED ON FOUR PERSONS IN NINETEEN EXPERIMENTS LASTING SIXTY-FIVE DAYS, AND MADE IN ATWATER'S RESPIRATORY CALORIMETER.

Subject under experiment and length of time.	Nitrogen.				Carbon.					Gain + or loss − of the tissues.		Energy in Calories.						
	Of the foods.	Of the fæces.	Of the urine.	Gain (+) or loss (−).	Of the foods.	Of the fæces.	Of the urine.	Of respiratory products.	Gain (+) or loss (−)	Proteids.	Fats.	Of the foods.	Of the fæces.	Of the urine.	Of the gain or loss of proteids.	Of the gain or loss of fats.	According to the calculation of material destroyed.	Measure in heat produced.
A. *Experiments made under conditions of rest.*	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.	Cals.
E. O., 4 days	19·1	1·7	18·1	−0·7	248·9	13·8	11·6	231·7	− 8·2	− 4·2	− 7·8	2655	143	128	−24	− 73	2482	2379
,, ,, ...	16·7	0·9	17·7	−1·9	217·1	6·7	13·3	214·6	−17·4	−12·0	−14·3	2441	76	135	−69	−135	2434	2394
,, ,, ...	20·8	1·3	19·5	0·0	270·7	10·6	13·9	224·5	+21·7	0·0	+28·3	2897	117	153	0·0	+266	2361	2287
,, ,, ...	19·1	1·3	18·4	−0·6	261·6	13·4	12·6	223·6	+12·0	− 3·6	+18·2	2717	142	149	−21	+171	2277	2309
,, ,, ...	19·8	1·4	19·5	−1·1	252·8	11·8	13·5	214·9	+12·6	− 6·9	+21·2	2701	127	147	−40	+199	2268	2283
,, 3 days	18·7	1·1	19·5	−1·9	245·8	11·1	15·1	205·2	+14·4	−11·7	+26·9	2596	125	173	−67	+253	2112	2151
,, 4 ,, ...	15·1	0·9	16·2	−2·0	239·0	7·4	12·2	207·3	+12·1	−12·4	+24·5	2513	82	142	−71	+229	2131	2193
,, 3 ,, ...	19·8	1·1	19·0	−0·3	244·9	10·2	12·2	216·4	+ 6·1	− 1·6	+ 9·0	2546	114	141	− 9	+ 84	2216	2176
,, ,, ,, ...	19·8	1·3	18·2	+0·3	299·7	10·5	11·8	230·9	+46·5	+ 1·7	+59·7	3061	116	136	+10	+561	2238	2272
Average of the above 9 exps. made on E. O.	**18·8**	**1·2**	**18·5**	**−0·9**	**253·4**	**10·6**	**12·9**	**218·8**	**+11·1**	**− 5·6**	**+18·4**	**2681**	**116**	**145**	**−32**	**+178**	**2280**	**2272**
A. W. S., 3 days . . .	15·5	1·0	15·4	−0·9	215·2	9·0	10·8	217·4	−22·0	− 5·6	−24·9	2264	100	126	−32	−234	2304	2279
J. F. S., ,, ...	17·7	1·0	16·4	+0·3	270·9	9·7	12·9	216·6	+31·7	+ 1·9	+40·4	2896	111	147	+11	+385	2242	2244
,, ,, ...	15·9	1·1	15·4	−0·6	233·2	9·4	11·0	196·1	+16·7	− 3·5	+24·4	2490	106	128	−20	+233	2043	2085
,, ,, ...	15·8	1·2	15·3	−0·7	245·8	10·0	10·9	210·7	+14·2	− 4·5	+21·8	2489	112	128	−26	+208	2067	2079
Average of the above 13 exps. (*At rest.*)	**18·0**	**1·2**	**17·6**	**−0·8**	**249·7**	**10·3**	**12·4**	**216·1**	**+10·8**	**− 4·8**	**+17·5**	**2636**	**118**	**141**	**−28**	**+165**	**2244**	**2241**
B. *Experiments on subjects working about 8 hrs. per day.*																		
E. O., 4 days	19·1	1·5	16·5	+1·1	336·7	12·4	12·5	345·2	−33·4	+ 6·9	−48·4	3678	139	125	+40	−455	3829	3726
,, ,, ...	19·8	2·2	18·1	−0·5	373·5	20·2	12·7	372·6	−32·0	− 3·0	−39·7	3862	219	133	−17	−374	3901	3932
J. F. S., 3 days . . .	16·0	0·8	16·0	−0·8	333·6	8·3	11·2	334·9	−20·8	− 5·0	−23·8	3487	93	134	−28	−227	3515	3589
,, ,, ...	16·1	0·8	15·6	−0·3	321·5	8·1	10·9	315·8	−13·3	− 2·3	−15·9	3495	91	129	−13	−151	3439	3420
,, ,, ...	16·1	1·2	15·7	−0·8	320·0	12·6	11·0	325·6	−29·2	− 5·0	−34·9	3487	142	119	−14	−333	3573	3565
,, ,, ...	16·0	1·2	16·7	−1·9	335·7	11·6	11·6	345·4	−32·9	−11·9	−35·0	3493	126	126	−54	−334	3629	3487
Average of the above 6 exps. (*during work*)	17·2	1·3	16·4	−0·5	336·8	12·2	11·7	339·9	−26·9	− 3·4	−33·0	3584	135	128	−14	−312	3647	3637
Average of the total 19 exps. (*states of rest and work united*)	**17·7**	**1·2**	**18·3**	**−0·6**	**282·2**	**11·1**	**12·1**	**283·1**	**−1·0**	**− 3·8**	**+ 1 3**	**2978**	**122**	**136**	**−19**	**+ 12**	**2727**	**2722**

constitutes the life, the function of the muscular organ—is lost.

Because this phenomenon, whatever may be its cause or its mechanism, consists simply in the power to convert energy from its passive chemical form into its active mechanical form. The same thing applies to nervous centres. Energy there is translated into feeling or thought but it is not exhausted in the process. The energy which is expended in the production of thought, judgment, comparison, reasoning, still continues to exist and, as Atwater's figures go to show, is found again undiminished at its exit from the brain. This is true even of the psychic phenomena of conscience, judgment or will power.

Atwater made one of these experiments, which lasted six days, to find out the influence of these psychic phenomena on the balance of energy.

A young American student, aged 26, was put into the respiratory chamber. The first period of two days was devoted to muscular exercise. During the second the subject remained in bed, eating, sleeping, and making only necessary movements. He devoted the two last days to the study of physics and pure mathematics. During these three periods the subject received an unvaried diet. In each case, mechanical work, rest or intellectual work, the quantity of heat proceeding from the apparatus corresponded *exactly to the amount introduced by the foods.*

If, therefore, the mechanical acts had disappeared, transformed by the dynamo into their equivalent in heat, the psychic acts—or their resultants, comparison, judgment, memory—would have persisted without having sensibly borrowed anything from the energy supplied by food.

In summing up all the experiments made up to the present time, that is to say, 155 days passed by subjects in the calorimeter, Atwater is able to affirm that 450,000 Calories thus collected by him in the course of the activity of subjects under examination represents, to nearly 50 Calories (allowing for a slight experimental error of one eight-thousandth) all the energy introduced into the calorimeter under the form of food.

Atwater's researches, as the above table shows, demonstrate *experimentally* that life—that is to say, the ordered succession of functional acts necessary to the preservation of the individual and to the harmonious working of his organs—in its various manifestations, does not consume any portion of its material energy, and is therefore not equivalent to it.

From quite another point of view, these experiments establish the fact that the average adult man, weighing from 60 to 70 kgs., living at ease, at a temperature of about 17° C., and *taking care* to avoid all work and all unnecessary movement, requires about 2,250 Calories per day—that is to say, 33 Calories per kg.

It was seen in the preceding chapters that an adult living in the open air and taking moderate exercise without actual work, has need of 38 to 39 Calories per day for every kg. of his weight. This slight excess—five to six Calories per kg. in the case of a man who takes a little exercise—is perfectly reasonable.

The experiments of Atwater permit of the amount of alimentary waste caused by labour to be calculated directly and with precision. They show that for a moderate amount of work, not excessive, of eight hours per day, a supplement of about 1,400 Calories is necessary. We shall return later to this important point.

These interesting observations have also permitted us to prove by means of experiment, a fact which had already been established in an abstract form, namely that the transformation of food into its equivalent in energy is independent of the nature of the intermediate physical states, whether chemical or vital. If the subject under experiment changes neither in nature nor in weight, this transformation must be the same as that which would be produced by these foods if they were transformed in the calorimeter into the excretory products rejected by the living subject.

In the light of these experiments it is now possible—perhaps for the first time with accuracy in the case of man, at least—to regulate the balance between the various animal functions: the quantity of oxygen consumed, of carbonic acid and water produced, of proteid matters and fat lost or gained in each case of the subject, and the comparison between the amount of latent energy lost and that of the caloric energy produced in the same period of time. These gains or losses of albuminoids or of fats are given in columns 11 and 12 of the above table. It will be seen that the loss in proteids has remained almost unchanged, whether the subjects under experiment were at work or in repose, the variation being from only 3·5 to 5 grms. a day. This merely indicates that the dietetic régime of those particular patients was poor in nitrogenous matters. But a characteristic point is that, during repose, they all stored up fat which they as invariably lost during work, the average quantity being 33 grms. in excess of what they received by means of food. This is an experimental illustration of the formula that work originates in the destruction, not of the muscular body, but of the fats and other ternary matters.

The experiments of Atwater once more established the fact, as proved by Boussingault, Pettenkoffer and C. Voit, that almost the entire quantity of nitrogen contained in the food of a healthy animal is found again in its excretions, liquid and solid.

The observations of the same authority have given more exact figures than any previously published with regard to the proportions in which every kind of alimentary principle is utilized by a man in health. These figures are given on p. 59. They show that

every alimentary element yields different quantities of heat, according to whether it is of animal or vegetable origin, and according to the régime to which it contributes.

The table on p. 43 gives the coefficients of utilization for every food and for every alimentary principle, whether albuminoid, fat or starch, the coefficient varying with the régime. We shall return to this point in the following chapter.

Finally, Atwater's experiments definitely establish the fact that certain substances, reputed by certain authorities to be toxic in their properties and by others to be at least useless and non-alimentary—alcohol, for instance—are consumed almost entirely in the economy, while others, on the contrary, although combustible, are not utilized by the economy in the production of energy, but exercise a stimulating influence on the nerves. We shall return to these interesting points in *Part II* of this Work.

VIII

ALIMENTARY EQUIVALENTS—ISODYNAMIC RATIONS—LIMITS OF MUTUAL SUBSTITUTION OF ALIMENTARY PRINCIPLES—INDISPENSABLE MINIMUM OF ALBUMINOIDS

WE have established by different methods the *ration of maintenance*, that is to say, the average alimentary ration of civilized man living in health, in a temperate climate and in a state of ease, or at least of relative ease. Before examining how this ration should be varied according as the subject lives in a glacial or warm temperature ; whether he works instead of resting ; whether he is a child, a young or an old man, in good health or an invalid, etc. ; it is right to ask if the daily ration and the manner of feeding generally adopted would not result from unnatural habits, from customs which have become gradually vitiated ; if the manner of feeding adopted by human agglomerations, by populations, by towns like London, Berlin or Paris, cannot be advantageously modified and made perfect, and by what character one could recognize the benefit established by these modifications, whether in the quantity of the food or in its character.

It appears to me, that in order to solve this delicate problem, there are two incontestable principles which should enlighten and guide us. The first is that the daily ration ought, in every case, to bring the individual the amount of energy indispensable to the carrying on of his functions, and that from this point of view all modifications of diet or substitution of one principle for another ought to be equivalent ; the second is that all change in diet, in quantity or quality, should have as a guarantee of its utility, or at least of its harmlessness, the maintenance in a state of health and of functional activity of the individual or of the communities which have adopted it.

Let us first ascertain what are the alimentary equivalences of the energy which they represent.

Isodynamics of Alimentary Rations.—The quantity of useful energy put at the disposal of the animal by each food, is measured by the number of Calories produced in the economy by the combustion or destruction of the whole of this food, which is really absorbed in the intestines.

The utilizable alimentary energy of the total ration is measured by the sum of the partial energies thus determined, and can be expressed in Calories.

Whatever their relative compositions may be, two alimentary rations will be called *isodynamic*, if their total energy corresponds to the same number of Calories thus calculated (*Rübner*).

The quantities of two or several alimentary principles will be called *isodynamic*, or isodynamically equivalent, when by their combustion or the definite modifications undergone in traversing the body of the animal, a similar amount of disposable energy will result.

Reciprocally, if the animal does not change in weight or perceptibly in chemical constitution, a certain quantity of an element (sugar for example) can be replaced in its ration by a quantity of some other element, such as fat, starch or albumin, so that a similar amount of energy under the form of heat or exterior work is produced in both cases. *Isodynamic quantities* is the name given to the alimentary principles which, under these conditions, can be mutually replaced. According to Rübner, the quantities of the following alimentary principles are isodynamic :—

	Quantities destroyed.	Corresponding heat produced in the Organism.
Fat	100 grms.	930 Cals.
Muscular albumin . .	243 „	do.
Legumin	257 „	do.
Cane-sugar	234 „	do.
Glucose	256 „	do.

On the other hand, as we have said in Chapter VI, concerning the measure of alimentary energy, Atwater, slightly correcting Rübner's figures, arrived at the following results, which indicate the number of Calories produced in the system, varying according to the origin of the food, by the dissimilation of 1 grm. of alimentary matter :

			Practical calorific coefficients.
Proteid matters	Food	Animal	4·25 Cals.
		Vegetable	3·55 „
		Mixed	4·00 „
Fatty matters	Food	Animal	8·95 „
		Vegetable	8·35 „
		Mixed	8·90 „
Starchy matters			4·00 „
Assimilable sugars			3·60 „

Furnished with these practical coefficients, if one would know the x isodynamic quantities of each of the alimentary principles, for example those which, in passing through the economy, will produce 100 Calories, representing by M the coefficients above, we shall have in each case :

$$xM = 100 \text{ hence } x = \frac{100}{M}.$$

By applying this formula, we shall obtain the following table of isodynamic quantities of each of the alimentary principles able to produce 100 utilizable Calories, while passing through the animal organism.

	Quantities producing 100 Calories while being destroyed in the system.
Proteid matters of animal origin	23·53 grms.
,, ,, *vegetable origin* . . .	28·19 ,,
,, ,, *mixed origin*	25·0 ,,
Fatty matters of animal origin . . .	11·18 ,,
,, ,, *vegetable origin*	11·97 ,,
,, ,, *mixed origin*	11·23 ,,
Starchy matters	25·00 ,,
Assimilable sugars	27·78 ,,

In all these calculations one must remember to deduct, in practice, the somewhat variable fraction for each alimentary principle which is not utilized in the intestinal tube, and which, in the case of mixed foods, diminishes the result of the general calculation by about 5·5 per cent. according to Rübner, and 4·5 per cent. according to Atwater.

The *isodynamic régimes* being those which produce by destruction, quantities of equivalent energy in the economy, it is easy to estimate them, as we have just seen, by using Rübner's or Atwater's coefficients.

But are the isodynamic régimes, composed according to the rules which we have just considered, equally efficacious ? In particular, can a considerable quantity of fat, sugar, starch be replaced isodynamically in the alimentary region, the one by the other in isodynamous quantities and, above all, can they be replaced by their isodynamic weights of albumin, and reciprocally ?

This question is of great practical and theoretical interest. *Practical*, because the market value of each kind of food differs according to its origin ; the cost of albuminoid foods used by man and animals is generally much higher than that of fat or starchy foods calculated by isodynamic weight, and because the net cost of alimentary régimes influence in a large measure the composition, the quantity, and in consequence the efficacy, of the régimes generally adopted. *Theoretical*, because it is important to know : 1st, if there is a minimum of albuminoid matter below which normal alimentation is impossible and, in the case where it exists, to what physiological necessity this minimum responds. 2nd, in the case where substitution, at least partial, of the proteid elements would be possible, it is necessary to determine in what measure and proportion the nitrogenous fats, sugars and starchy matters can mutually replace themselves.

As has already been said, it is not possible for an animal to create the whole of its constitutive albuminous elements. On the

contrary, it continually destroys those of which it is formed, and the incessant secretion of urea is a proof of this dissimilation. It is then necessary for us to provide the animal with the albuminoids which it cannot do without, and which it cannot manufacture with the fat elements or the carbo-hydrates, even if they are accompanied by nitrogenous organic products nearest to the albuminoid bodies, or the more or less complex amides such as tyrosin, leucin, glutamin, asparagin,[1] etc.

If these albuminoid matters are necessary, are they sufficient? Provided that an animal is fed with a superabundance of muscular flesh, for example, is it possible to entirely abolish the non-nitrogenous ternary substances, sugars, starches, fats? C. Voit,[2] C. Voit and Bischoff, Pettenkoffer and Voit,[3] and Pflüger[4] have tried to feed dogs with lean meat only. They have succeeded, and the animals have often lived under these conditions for several months and have even, during this period, done a considerable amount of work. But all these experimenters have remarked that, in this case, the quantity of muscular flesh necessary to nourish the animal while keeping up its weight is very considerable, a great part of the food being destroyed and unassimilated in order to reproduce the fat which always tends to disappear and the sugar which is incessantly consumed in muscular contraction. If one further increases the quantity of meat, it is thrown out in nature, as the analysis of the fæces and the proportional non-absorption of oxygen indicate. This is demonstrated by the following figures, for which we are indebted to C. Voit:

ENRICHMENT OR LOSS OF THE ECONOMY (DOG) SUBMITTED TO AN EXCLUSIVE DIET OF LEAN MEAT.

Lean meat introduced daily.	Destroyed albuminoid matter calculated after the eliminated nitrogen.	Gains (+) or losses (−) in the economy of nitrogenous matter.	Gains (+) or losses (−) in the economy of body fat.	Oxygen absorbed.	Oxygen necessary to oxidize the lost matters.
grms.	grms.	grms.	grms.	grms.	grms.
0	165	−165	−95	330	329
500	599	− 99	−47	341	332
1000	1079	− 79	−19	453	398
1500	1500	0·0	+ 4	487	477
1800	1757	+ 43	+ 1		592
2000	2044	− 44	+58	517	524
2500	2512	− 12	+27	(average)	688

[1] Weiskie and Munk have shown that asparagin possesses an economic action over the existing albuminoids, but it cannot replace them. M. Fiquet has established (in my laboratory) that the amides derived from the very careful hydrolysis of the albuminoids could no longer replace them.

[2] *Zeitsch. f. Biolog.*, Bd. V, pp. 344, 444; Bd. X, p. 223.

[3] *Ibid.*, Bd. VII, p. 133.

[4] *Annales of Pflüger*, Bd. I, p. 98.

These experiments show that it has been possible to keep a dog (weight 35 kgs.) in a state of *albuminoid or nitrogenous equilibrium* whilst feeding him with meat only, but to do this it was necessary that the quantity given should be as much as 1,500 grms. a day; whereas with a normal mixed diet, 530 grms. only of muscular flesh suffices for a man of twice the weight. The numbers show also that, proceeding from 1,500 to 1,800 grms., if the muscular tissue freed from fat is still increased, the animal, far from profiting by it, loses the albuminoid nitrogen whilst gaining a little fat.

On the other hand, we see that if the organism of the subject studied had formerly been submitted to a diet poor in proteid matters, his daily loss in nitrogen would be diminished and from that time a smaller quantity of albuminoids would suffice to maintain the nitrogenous equilibrium. Briefly, the maintenance of this equilibrium is the ordinary function of the animal. If it has been previously impoverished in albumin, it will lose a little of it each day, and a minimum quantity of alimentary contributions will cover this loss; if, on the contrary, before the experiment, it had received an abundant quantity of nitrogenized foods, and so acquired as much nitrogen as it could possibly store, the gain in nitrogen would only be very slight or nil, and its losses would vary very nearly at will with the quantities of alimentary albuminoids. This is indeed the result of C. Voit's experiments.

The minimum ration of albumin necessary to maintain the nitrogenous equilibrium of the subject, depends on his present state and his former method of nutrition, and the experiments made relative to this determination should only be performed on subjects in perfect health who have been normally fed for several days and whose weight does not vary.

We see how much these conditions tend to real doubt, and how much uncertainty and difficulty is presented by the method of fixing the nutritive balance according to the conditions which maintain the nitrogenized and carbonated equilibrium of the subject we experiment upon.

But there are still other causes of indetermination.

By a mechanism which in a measure escapes us, the animal, whether it receives it or not by its foods, tends always to store up a reserve of fat. If then this is already sufficient, the quantity of albumin stored up by an exclusive or preponderant diet of lean meat, will increase more than if the animal had already exhausted its fats. In other words, a smaller quantity of albumin will be necessary to the fat animal to attain its nitrogenized equilibrium.

Fat exercises then an economic action on the consumption of alimentary matters. An average ration of meat which maintains the nitrogenized equilibrium will cause at the same time a deposit

of muscular flesh and fat, if one adds to the régime an excess of these latter materials.

Reciprocally, an excess of flesh food will increase the fatty reserves by the same quantity of body fat introduced.

But, whatever may be the initial state of the organism, feeding exclusively on albuminoids cannot contribute long to increase the reserves, whether proteid or fat, of the animal, and a diet composed exclusively of flesh soon becomes repugnant and injurious. The same thing happens in a man as in a dog. Experimenting on himself, J. Ranke, who was fat and relatively poor in flesh, was able to take during two days 2,000 grms. of meat in twenty-four hours, but from the third day, although well served and appetizing in appearance, the meat provoked nausea, headache, and he could only absorb about 1,280 grms. These quantities of albuminoids would have been less nauseating if Ranke had been thinner and if, by very active physical exercise, he had constantly burnt up the fats which that incessant advent of compound proteid matters in excess tended to accumulate in his tissues.

All the albuminoid substances : fibrin, gelatin, powdered lean meat, etc., have led to the same results. When given exclusively to man or animals (above all in the case of subjects at rest) they have not been able to support them for long, and great difficulty has been found in maintaining the nitrogenized equilibrium by their means.

On the contrary, if to a purely meat diet one adds some fat, sugar, starch, bread, vegetables, not only all disgust disappears, but the quantity of albuminoids necessary to compensate for the losses of the economy in nitrogen, diminishes considerably. In a word, as we have already said, the ternary substances pave the way for the nitrogenized assimilation and lessen the dissimilation of the proteid substances. This is what the following figures, relating to Voit's experiments upon himself and the observations of Forster, show :

	Absorbed meat.	Starchy matters.	Fats.	Dissimilated albuminoids.
	grms.			
C. Voit :				
1 day	2000	0	0	2044
5 days	2000	250	0	1793
Next 5 days . . .	2000	0	250	1883
Forster :				
4 days	500	0	300	436
Next 3 days . . .	500	0	0	522

Fat, sugar and many other carbo-hydrates favour then the

assimilation of proteid substances or hinder their dissimilation, and, reciprocally, these can to a certain point be substituted for ternary matters.

Even in a state of absolute rest, an animal destroys a part of its albuminoids, and as it cannot reproduce these substances entirely, it is necessary that alimentation should continually provide him with them. In a state of rest and abstinence, even when prolonged, man and animals excrete daily a quantity of urea which is about the half of that which they would throw off if they fed normally. The result of this remark would seem to be that if, in the ordinary state, 107 grms. of albumin are suitable for the adult, 50 to 55 grms. ought to suffice to repair his nitrogenized tissues if he remains in absolute repose. But this is not absolutely the case as will be shown.

Experience has shown that whatever the quantity of ternary matters (sugar, fat, starch) introduced by alimentation, one never goes so far as to protect the animal against the dissimilation of its albuminoid tissues. If carnivora and omnivora are fed exclusively on carbo-hydrates or fats, they perish rapidly, nearly as quickly as if they had been submitted to a régime of complete inanition (*Magendie*). They consume their nitrogenized tissues, while sometimes laying up a small store of fat, and die as if they had been starved. But as soon as one adds to this exclusive diet a little meat, *the excretion of urea diminishes* immediately, their weight increases and they grow fat. Thus a small quantity of albumin would appear to be sufficient for their needs. But this proportion cannot be inferior, nor even strictly equal, to that which they lose during inanition. Munk has demonstrated this by giving to a dog with a diet sufficiently strong in carbohydrates and fats, the *exact* quantity of meat necessary to repair its daily losses in nitrogen. The nitrogenized equilibrium maintains itself, it is true, but at the end of some weeks, the animal is seized with intestinal troubles, he can no longer digest the alimentary fats, he becomes jaundiced, he refuses nourishment and dies. It is because in this diet, the stimulant of the trophic centres, meat and its extracts, is insufficient. Besides, variety is wanting, and without doubt, it no longer brings such or such specific elements in sufficient quantity or under forms which are suitable to the functioning of certain organs.

In alimentation, the carbohydrates can replace the fats almost entirely, and, reciprocally, the fats can be substituted almost completely for the carbo-hydrates. But these last substances protect the albumin of the tissues against dissimilation in a manner much more powerful than a similar quantity of fats, as the following figures show :

Flesh absorbed.	Ternary substances absorbed.	Albuminoid tissues disappeared.	Gains or losses of the organism in albuminoids.
grms.	grms.		
500	250 fat	558	− 58
500	300 starch	466	+ 34
800	250 carbo-hydrates	745	+ 55
800	200 fat	773	+ 27
2000	250 carbo-hydrates	1792	+208
2000	250 fat	1883	+117

Moreover, the carbo-hydrates are not only opposed to the dissimilation of the albuminoids of the system, but also to that of the fats, the weight of which they even contribute to increase.

Sugars and starches do not appear to be, however, absolutely necessary. In certain cases, and thanks to custom, man can nourish himself almost exclusively on fat meats. It is so with the Esquimaux, the Greenlanders, the Ostiaks, the inhabitants of the borders of the Red Sea, the keepers of the flocks on the American pampas, who live almost entirely on the products of their fishing and hunting.

The fat of the meats which they consume and the small proportion of glycogen which accompanies them is sufficient to make them assimilate the proteid substance. It follows then that we can accustom ourselves to live on fat meat, but cannot fail to recognize the fact that man, by his teeth, his digestive organs, his tastes, is omnivorous and frugivorous, and that the capacity to live exclusively on meat is an exception created by necessity.

From this discussion we shall conclude that if albuminoid matters alone are absolutely indispensable in food, their good assimilation and utilization can only be realized in the presence of the ternary bodies: fats, sugars and starchy substances. Thanks to their combination in the relation of 100 parts of the first to 400 to 450 of the second, the animal maintains his weight and health with a minimum of alimentary expense, and while acquiring, as we shall see, the maximum of resistance to illness and of production in mechanical labour.

Isoglycosic and Isodynamic Regimes.—M. Chauveau, basing his theory on his remarkable observations which show that only glucose which burns in the working muscle is the direct and nearly unique principle in the production of mechanical energy, considers that the *equivalence* of foods from the standpoint of their capability to furnish work, ought to be calculated according to the quantity of glucose that these foods are able to contribute to produce in the economy. The figures of Rübner and Atwater, proportional only to the calorific energy furnished by the foods,

are in the estimation of M. Chauveau, only *isothermic* coefficients; the real *isodynamic* coefficients should be calculated according to the isoglycogenic power of each alimentary principle. I give below the isoglycogenic weights of the fundamental principles, according to this author, compared with their isodynamic weights. The isothermic and isodynamic coefficients of fat being the highest, we will take this as our unit in both cases:

	Isodynamic weights.	Isoglycosic weights.
Albumin	2·35 grammes	2·01 grammes
Fat	1·00 „	1·00 „
Starch	2·29 „	1·46 „
Saccharose	2·35 „	1·53 „
Glucose	2·55 „	1·61 „

Thus, according to M. Chauveau, 1 grm. of fat or 1·53 grm. of saccharose would be able to produce in the system, the first by oxidation, the second by reduction, the quantity of 1·61 grm. of glucose or 1·45 grm. of glycogen. In the light of this fact these quantities are isoglycogenic and *isodynamic*. They would be also isodynamous with 2·01 gr. of albumin, a quantity which can produce by combustion in the economy 1 grm. of fat.

The isodynamic value of a food according to M. Chauveau, should equal in weight each of its constitutive principles multiplied by its isoglycosic equivalent. It will thus be seen: 1st, that the isoglycosic equivalents of M. Chauveau appear somewhat vague: 2nd, the very principle which he urges does not seem to have been conclusively demonstrated.

Minimum Quantity of Albuminoids Necessary to the Daily Ration.—We have just seen that the albuminoid substances cannot be supplemented in the alimentary ration, but that according to the actual state of the subject and the nature of the ternary bodies which enter into his régime, the nitrogenized equilibrium can maintain itself with quantities of very different proteid matters. Owing to this, F. Hirschfeld, who weighed 73 kgs., was able to place himself in a nitrogenized equilibrium, thanks to a diet which only contained 43·3 grms. of albumin, a day, but on condition that he took at the same time 165 grms. of butter and 350 grms. of carbohydrates. Again, in two subjects weighing respectively 64 and 65 kgs., Klemperer was able to maintain the nitrogenized equilibrium with an expense of 30 grms. of albumin only, while administering daily the excessive quantities of 262 grms. of fat, 406 grms. of carbo-hydrates and 199 grms. of alcohol.

Thus, with some exceptional diets, we can greatly vary the quantity of proteid matters sufficient to maintain the nitrogenized equilibrium.

On the other hand, it has been shown that it is a matter of some importance whether these albuminoids are of animal or vegetable origin. The intestinal utilization of the latter is only eighty-seven hundredths or even eighty-three hundredths of that of the former. Thus, it is essential to distinguish between the two when calculating the maximum quantity of albuminoids necessary in twenty-four hours.

With so many causes of variation, it would be better to consult the facts once more before fixing the minimum of albuminoids.

During the Siege of Paris (1870–71), the quantity of albuminoids absorbed by the population, to a large extent deprived of meat, vegetables and bread, was certainly less than half of the usual quantity, the official ration was indeed fixed at 30 grms. of horse-flesh and 120 grms. of bread of a very bad quality, foods to which each inhabitant could, if he had any supplies, add a little fat, rice, various preserved fruits, wine, alcohol, etc. With such a severe ration, the general health of the healthy part of the population was well maintained in spite of a rigorous winter and various epidemics. The battalions of soldiers guarding the trenches during the very cold months of December 1870, and January 1871, formed of young men of 21 years, badly clothed, giving themselves up to work often very laborious, received the following diet as I have ascertained from the note-books of the Administration which distributed the provisions. I have completed these data by including small purchases of food which these young soldiers added themselves to their meagre rations. I give below the result of my inquiry on this subject in tabular form :

Food per day.	Weight of the fresh aliments.	Proteid matters.	Fats.	Carbo-hydrates.
	grms.	grms.	grms.	grms.
Fresh meat (or 100 grms. of preserved meat)	175	35	9·45	0·87
Rice (or beans, very seldom) . .	80	4·4	0·4	64
Soldiers' bread	250	17·5	2·85	251·9
Biscuit	250	22·5		
Fat	20	—	19	—
Coffee (officially delivered) . .	30	3·3	—	6·50
,, (bought by the men) . . .	25			
Sugar (officially delivered) . .	20	—	—	39
,, (bought by the men). . .	20			
Wine	125	—	—	95·4
Brandy	75[1]			
Totals	—	82·8	31·70	457·4

Thus, although suffering a little from hunger, but generally

[1] Wine and brandy are calculated here in corresponding carbo-hydrates.

in good health, these young people were able to withstand a very cold winter, with about 83 grms. of albuminoids, the proportion of animal origin per day being 35 grms. only.[1]

The total of their ration corresponded to 2,470 Calories.

According to the composition of portions and half portions distributed to the workmen frequenting the *popular restaurants* of Berlin, Hirschfeld thus estimates the average nourishment of the poor population of Northern Germany :

Daily.[2]	Average weight moist substances.	Average weight dry substances.	Albuminoid matters.	Fats.	Carbohydrates.
	grms.	grms.	grms.	grms.	grms.
Principal repast (from 12 to 2 o'clock ; half portions)	650	150	25	15	80
Bread	600	390	41	6	300
Fat and butter	80	—	—	72	—
Cheese	50	—	14	3	—
Coffee in the morning and soup in the evening	—	—	8	4	60
Totals			88	100	440

This population, generally healthy, appears then to satisfy its daily expenditure with an alimentation in which we find only 88 grms. of albuminoids daily. The ration so constituted would give 2,800 utilizable Calories.[3]

On the other hand, the statistics collected by Payen show that in convents, amongst those who lead a sedentary life without the power or will to increase a dietary strictly sufficient, provided they do not undertake any fatiguing work, good and even flourishing health is maintained, except for a number of gastric

[1] It is necessary to add daily *about* 10 grms. of albuminoids borrowed from their tissues and proportional to their emaciation, which amounts altogether to 93 grms. of albuminoids per day.

[2] An estimate founded on the food of the workman of Berlin in the popular restaurants. He generally takes a half ration to which he adds a little bread, butter and cheese, plus coffee in the morning and soup in the evening. The *half ration* in the middle of the day is composed of about 560 grms. of white haricot beans, potatoes and beef ; or 560 grms. of peas, potatoes and pork ; or 560 grms. of fish and potatoes ; or 600 grms. of fat soup with strips of paste and boiled beef.

[3] In reality, the fat and butter have been arbitrarily brought by Hirschfeld to the total amount of 72 grms. besides some 28 grms. of the midday repast and 4 grms. of the evening soup. I believe that this amount of 72 grms. is too high, the German workman not as a rule receiving 100 grms. of fat in his daily ration. Placing 80 grms. of fat and butter instead of 100 grms., the ration of this workman would only respond to 2,262 Calories, a number which corresponds to the average Parisian food. But Hirschfeld has not taken into account in his calculation alcohol or beer, which ought to raise *approximately* the number of Calories disposed of by the average German workman of Berlin from 500 to 600.

ailments of a nervous or inflammatory character, on condition that there is supplied to the organism daily 12 grms. to 12·5 grms. of alimentary nitrogen, a figure which would correspond to 75 or 80 grms. of assimilable albuminoids. Yet, in this case, they are borrowed for the most part from vegetables.

If we determine indeed the needs of the organism according to the dissimilation of nitrogenous principles, we see that man at complete rest, submitted to inanition, dissimilates at the expense of his tissues, be it in the form of urea or any other form, about 12 grms. to 12·5 grms. of nitrogen corresponding to the destruction of 77 to 80 grms. of albuminoids calculated dry.

Thus the quantities of 77 to 88 grms. of albuminoids, on an average 82 to 83 grms., seem to be the minimum required in the alimentation of men in our climates of an average weight of 63 to 70 kgs. for the maintenance of his health. This minimum quantity of albumin corresponds to 1·27 grms. of albumin per kilogramme of body weight per day, for the mean weight of 65 kgs.[1]

But we know also that 2,000 to 2,200 Calories at the least, are necessary to man each day for his maintenance. The 82 grms. of albuminoids only furnish him with 330 Calories; it follows that 1,800 Calories need to be provided by the fats and the carbohydrates in this alimentation reduced to the minimum of albuminoids.

[1] We cannot then agree with M. G. Bordet that the number 0·75 grms. of albumin per kilogramme per twenty-four hours is sufficient to maintain the nitrogenized equilibrium (See *Bull. thérapeutique*, December 10, 1900); especially if the individual does not remain completely at rest, in bed. The numbers furnished by M. Lapicque stating the demands in albumin, have nearly all this drawback, that they relate to a small number of individuals who were under observation for only a very few days. They are, however, so interesting, because they relate to individuals of different races, that I give the numbers here:

	Body weight.	Albumin per day.	Albumin per kg. of body weight.
	kgs.	grms.	grms.
Hirschfeld (excess of ternary body)	73	39	0·60
Kamagava	48	54·7	1·14
Breisacher	55	67·8	1·23
Japanese	50	60·0	1·03
Japanese student	46	52	1·19
Abysinnian	52	50	0·96
Malay	52	60	1·15

Thus it is established that races accustomed to vegetable food poor in albumin (rice, sorghum, etc.) are content with 1 grm. to 1.2 grm. of albumin per kg. per day, whilst doing a moderate amount of work. It is very nearly the same number as we deduced earlier from our own observations.

On the other hand, in calculating some of the practical needs which introduce into our daily food at least 50 grms. of fats, in recalling besides that these can be easily substituted by carbo-hydrates which readily transform themselves into fats in the economy, it is evident that the alimentary ration of the adult in relative repose, and only absorbing the *indispensable* proportion of albuminoids, ought to contain at least :

	grms.	Calories.
Albuminoids	82	328
Fats	50	455
Carbo-hydrates	388	1,417
Calories calculated		2,200

Such will be the régime of the adult, in relative repose, reduced to the minimum of nitrogenous and ternary elements. If he is doing only very restricted work, it is nearly sufficient for his maintenance in our climates. It is a poor diet, that of the prisoner, of the monk, of the unemployed workman, of the sedentary citizen. It suffices to maintain health, it even allows of a certain amount of activity, putting at their disposal 2,200 Calories, when 1,900 would suffice in absolute repose. Resting in bed, 77 grms. of albumin, 50 grms. of fat and 255 to 300 grms. of starch or sugar, i.e. a régime of 1,800 to 2,000 Calories would be quite enough. It is noticeable that this alimentation, thus reduced to the minimum of proteid bodies, is also that which produces the least nitrogenous waste. It will serve us as an example of how we should diet the gouty and the arthritic, and the patient whose liver, kidneys or heart are in such a state as to demand that these organs should be fatigued as little as possible. But this régime would suffice neither for the workman who is continually employed, nor for the inhabitants of cold climates, nor for the convalescent who has exhausted his reserves. Providing him only with the indisputable minimum, it leaves the individual in so precarious a state that he is incapable of resisting the attacks of fatigue and the influence of disturbing and morbid agents.

[1] By *Calories gross* I mean the number of Calories calculated according to the hypothesis of the absorption and combustion of the aliments introduced in the form of CO_2, H_2Cl and urea.

IX

RATION OF WORK COMPARED WITH THAT OF MAINTENANCE—THE YIELD OF THE HUMAN MACHINE IN MECHANICAL WORK

THE alimentary rations which we have calculated until now are those of the adult in comparative ease, *in a régime of maintenance.* We have fixed them, for absolute repose, at 80 grms. of albuminoids, 50 grms. of fats and 250 to 300 carbohydrates ; for relative repose, that is to say in a state of activity without actual work, at 107 grms. of albuminoids, 65 grms. of fats and 400 grms. of sugar and starches. If man performs mechanical work, he must supplement his food in proportion to this particular loss in energy.

One admits that a good workman who gives himself up to sustained exercise, without excess, provides in eight or nine hours *a utilizable amount of labour* of 80,000 to 100,000 kilogrammetres. But the utilizable amount of labour depends on the mode of execution and the employment of *real labour,* and it is this which it is well to know if it is a question of calculating the expenditure in foods capable of being transformed into dynamic force. To make this calculation, it is necessary that the workman should be placed under conditions where it is easy to keep an account of the secondary labours of friction, displacements, movements of the body, respiratory acts, etc., which accompany every mechanical action, and which, added to the useful toil, represent the sum of the expenditure of energy transformed into force.

The following are the observations which I have made on this subject.

A good workman can raise in nine or ten hours from 140 to 150 hectolitres of water, 10 metres in height, by means of a good suction and water pump. This work readily executed *and continued during several consecutive days* by the workmen in our warehouses and wine cellars, reduces the losses of mechanical energy by friction, useless movements, displacements of the body, etc., almost to a minimum. In working the handle of the pump which moves in the liquid, the workman does not displace himself in space, but at each stroke of the piston (about 12,000 in nine to ten hours), in the same time that he lifts up the column

of liquid, he raises and lowers successively the centre of gravity of the upper part of his body. He must overcome the friction of the piston of the pump and flywheel, frictions which are very slight in this case. Finally, his heart and respiratory muscles work on their part with an energy greater at least by a half than in a state of repose, in forcing the blood through the capillaries, and in balancing the elasticity of the vessels and atmospheric pressure. The whole of all this work is calculated in kilogrammetres, in the following table :

Filling of a tub of 150 hectolitres in carrying water to a height of 10 metres	150,000	kilogrmts.
Raising of half of the body (32 kgs.) for each piston stroke	52,700	„
Work to overcome the resistance of the pump and fly wheel, about	9,500	„
Excess of the work of the heart and respiration in comparison with a workman at rest	[1] 38,250	„
Small expenditures corresponding to the supplementary work of 24 hours after the work	10,000	„
Total of actual expended work	260,450	kilogrmts.

Frankland has found, on his part, 270,000 kilogrammetres for the *total day's labour* of a good workman labouring just to the border of fatigue, and I have calculated that a good climber performs a *total labour* of 260,000 to 280,000 kilogrammetres in ascending in eight to ten hours from 2,200 to 2,500 metres. Out of these 270,000 kilogrammetres 160,000 to 170,000 correspond to the lifting up of the body while ascending.

One may then admit that a good workman furnishes in a day of eight to ten hours from 260,000 to 280,000 kilogrammetres, out of which 25 to 65 per cent. are utilizable, according to the nature of the work done and the machine employed.[2]

In order to produce these 260,000 kilogrammetres in their day's work, workmen in the wine warehouses of the South of France consume in the autumn as *additional daily foods* :

Bread and its analogues	400 grms.
Fat	24 „
Meat	200 „
Fresh vegetables	200 „
Wine at 9°	1 litre

[1] Allowing here for the deduction for the additional energy expended by the labour of the workman and for the nature of this work, we only reckon the excess of the work of the heart and the thoracic muscles ; still, the work of the heart disappears almost entirely as work, transformed as it is, into friction and internal heat.

[2] My workman at the pump rendered 58 per cent. of useful work out of 100 of the total work. My climber, weighing 70 kg., ascending in eight hours from 2,200 metres in altitude, produced 154,000 kilogrammetres of work for a total expenditure of 270,000 kilogrammetres, being 56 per cent. of useful work.

These foods contain the fundamental nutritive principles, albumins, fats, sugars and starches, in the following proportions :

		Albuminoids	Fats.	Carbohydrates.
Bread and its analogues.	400 grms.	33 grms.	4·2 grms.	200 grms.
Meat	200 „	37 „	4 „	1 „
Fats	24 „	—	21 „	—
Fresh vegetables . . .	200 „	8·5 „	6·1 „	8·2 „
Wine at 9° [1]	1 litre	—	—	130 „
Total	—	78·5 grms.	35·5 grms.	339·2 grms.

Such is, for a workman forced to a work mechanically regulated and of which one can pretty easily calculate the total, the *supplementary ration* which corresponds to this work. If we add to this expenditure the strict alimentary ration of the workman at ease, we shall have :

	Strict ration of rest.	Supplementary ration of work.	Total ration of work.
Albuminoids . . .	78 grms.	78·5 grms.	156·5 grms.
Fats	50 „	35·5 „	85·3 „
Carbo-hydrates . .	370 „	339 „	709 „

We shall calculate directly how many Calories this ration corresponds to, and what is its coefficient of result in mechanical energy. But first it will be very interesting to compare the total expenditure of this workman confined to a definite, continuous and regular work, with that which results from work, which might be called unregulated, of the agricultural labourer of the same country who happens probably to furnish daily the same total effort, if one judges him by his same fatigue, but with whom the daily occupations are very varied and often broken up, in the same day, by repose and by laborious work of every kind.

In order to make this interesting calculation I have chosen two average peasant families, living and working very regularly, not drinking any alcoholic liquors other than wine, and that taken very moderately. One of these families was composed

[1] We shall establish in Part II that wine is really an aliment, suited in a large measure to furnish by combustion, in the economy, a little more than nine-tenths of its potential energy, and in our calculation, we transform here the alcohol of this wine into corresponding glucose.

of six persons, the other of eight (of whom two were women and one a child of seven—these three persons counted as two adults). These thirteen people consumed exactly, in 5,003 days, the food which I indicate in the first column of the following table and which I also calculate in alimentary principles per head and per day :

AVERAGE ALIMENTATION OF THE AGRICULTURAL LABOURER OF THE SOUTH OF FRANCE.

Kind of alimentation	Total in 5,003 days.	Per head and per day.	Aliments containing per day :		
			Albumin.	Fat.	Carbo-hydrates.
	kgs.	grms.	grms.	grms.	grms.
Bread [1]	4277	855	69·7	6·8	420
Meat	771	154	23	5·9	1·2
Fat and oil	304	61	—	55	—
Potatoes	2750	526	6·8	1·0	105·5
Dry vegetables [2]	890	178	40	3·4	95
Green vegetables	1055	212	9·5	7·0	25
Wine (67 hectolitres at 9°)[3]	6700	1330 cc.	—	—	174
Supplementary sugar and coffee	—	10	—	—	10
Totals	—	—	149·0	79·1	829·7

This ration thus established differs very little from that which we have already calculated (p. 87) for the workman subjected to the regular work of the pump in our wine vaults. We have :

Alimentary diet per day.	Workmen in wine vaults.	Agricultural labourers.
Assimilable albuminoids	156·5 grms.	149·0 grms.
Fats	85 „	79·1 „
Carbo-hydrates	709 „	829·7 „

In order to obtain the maximum of work from the French workmen employed in the construction of the Rouen railway, Gasparin (*Traité d'agriculture*, t. V) relates that they were obliged to put them on the régime of the English workmen

[1] Of which 20 kgs. are Italian pastry.
[2] Principally beans with about one-fourth dry peas.
[3] The calculation of wine for one day gives 1·33 litres, which, at 9° correspond to 96 grms. of alcohol, corresponding to 192 grms. of sugar. Nine-tenths of this alcohol burning in the economy, the corresponding sugar is then 174 grms. per day.

charged with the same work; they received 660 grms. a day of raw meat, 550 grms. of bread, 1,000 grms. of potatoes, 50 grms. of fat and 2 litres of beer. This diet corresponds to the following composition, calculated in fundamental assimilable principles:

	Per day.	Albuminoids.	Fats.	Carbo-hydrates.
	grms.	grms.	grms.	grms.
Raw meat . .	660	98	28	3
Bread . . .	750	61·6	6·6	350
Potatoes . . .	1000	14	1·5	201
Fat and butter .	50	—	48	—
Beer (2 litres)[1] .	—	1	—	165
Total . . .		174·6 grms.	84·1 grms.	716 grms.

Here is, still according to the data of the same economist, the nourishment of the labourers of the Département du Nord and the agricultural workmen of the canton of Vaud. I reduce them both to the ration of twenty-four hours; but the numbers furnished by M. de Gasparin, totalizing the alimentation of a certain number of important farms, and for the whole year, correspond to very high totals and in consequence to very safe averages.

LABOURERS OF THE DÉPARTMENT DU NORD.

Kind of alimentation.	Daily.	Albuminoids.	Fats.	Carbo-hydrates.
Rye flour	880 grms.	97·0 grms.	18·0 grms.	572 grms.
Flour	82 „	8·7 „	0·8 „	59·8 „
Barley	130 „	14·8 „	2·0 „	91·9 „
Potatoes	960 „	12·4 „	1·5 „	180 „
Peas and dry vegetables	55 „	10 „	0·7 „	28 „
Meat (chiefly beef) .	82 „	14·7 „	4·3 „	0·3 „
Bacon	30 „	2·0 „	23 „	—
Butter	55 „	—	53 „	—
Milk.	450 cc.	17 „	16·2 „	20 „
Beer.	1 litre	0·5 „	—	73 „
Salt	33 grms.	—	—	—
Total	—	177·1 grms.	122·5 grms.	1025 grms.

[1] Calculation for beer: 2 litres of beer at 4° (average) represents 64 grms. of alcohol corresponding to 128 grms. of glucose, of which nine-tenths, or 115 grms., are counted as corresponding to the alcohol burnt up. It is necessary to add to 2 litres of beer, 50 grms. of sugar or dextrins and 1 grm. of albumin.

RATION OF WORKMAN AT WORK

ALIMENTATION OF THE AGRICULTURAL LABOURERS OF THE CANTON OF VAUD (according to Gasparin).

	Per day.	Albuminoids.	Fats.	Carbo-hydrates.
Bread	784 grms.	63 grms.	6·6 grms.	390·0 grms.
Potatoes . . .	1000 „	13 „	1·5 „	200 „
Green vegetables	110 „	1 „	0·5 „	4·9 „
Lentils and dry vegetables . .	35 „	7 „	0·8 „	18 „
Dry fruits . .	35 „	3 „	—	8 „
Meat	157 „	27 „	7·2 „	0·7 „
Cheese	79 „	23 „	24 „	—
Butter	29 „	—	26 „	—
Milk	630 cc.	23·0 „	22 „	28 „
Wine	330 „	—	—	64 „
Cider	275 „	—	—	
Coffee	—	—	—	
		160 grms.	91·6 grms.	713·6 grms.

Here is again the detail of some rations which have been put to proof, *in times of war or campaign*, in the armies of different nations :

RATION OF THE FRENCH ARMY DURING WAR.

Kind of diet.	Per day.	Albuminoids.	Fats.	Carbo-hydrates.
Bread (or biscuit 735 grms.)	1000grms.	70·6 grms.	4·60 grms.	526 grms.
Raw meat	300 „	50·2 „	13·02 „	1·5 „
Vegetables in grain . .	60 „	15·8 „	1·14 „	32 „
Sugar	21 „	—	—	20 „
Coffee	16 „	0·5 „	—	—
Wine at 9·5° (about) . .	250 cc.	—	—	52 „
Brandy	60 cc.	—	—	
Salt	16grms.	—	—	—
Total		137·1 grms.	18·76 grms.	631·5 grms.

DAILY RATION OF THE FRENCH SAILOR DURING A CAMPAIGN.

Kind of diet.	Per day.	Albuminoids.	Fats.	Carbo-hydrates
	grms.	grms.	grms.	grms.
Bread or its equivalent of biscuit . .	750	61·50	6	375·0
Fresh meat or its equivalent of salted meat	300	62	15·3	1·4
Beans, peas, haricots (or their equivalent of rice, meat or cheese)	120	27·6	1·8	69
Butter and olive oil	21	0·1	17·5	—
Sorrel or sour-krout	15	0·3	0·1	1
Sugar	25	—	—	25
Coffee (infusion of 20 grms.) . . .	—	—	—	—
Vinegar, pepper, mustard	—	—	—	—
Wine (or its equivalent)	460	—	—	120
Brandy	60	—	—	
Salt	22	—	—	—
Total	1773	155·5	40·7	591·4

LARGE WAR RATION OF A PRUSSIAN SOLDIER (IN TIME OF WAR AND IN A CAMPAIGN). *Regulation July* 4, 1867.

Kind of ration.	Per day.	Albuminoids.	Fats.	Carbohydrates.
	grms.	grms.	grms.	grms.
Bread	750	61·50	6	375
Meat	500	104·50	25·2	2·3
Rice, 160 grms. (or barley 120 grms., or dry vegetables 320 grms. or potatoes 2000 grms.)	160	17·3	2·5	247.0
Roasted coffee	24	—	—	—
Total		183·3	33·7	624·3

RATION OF THE ENGLISH ARMY IN CRIMEA.

Kind of ration.	Daily.	Albuminoids.	Fats.	Carbohydrates.
	grms.	grms.	grms.	grms.
Bread	680	54·4	5·8	340
Meat, fresh or salted	483	96·6	24·5	2
Rice	56	3·2	0·6	44·8
Sugar	56	—	—	56
Coffee	28	—	—	—
Tea	7·8	—	—	—
Rum	14	—	—	14
Lemon juice	28	—	—	—
Salt	14	—	—	—
Pepper	7	—	—	—
Total		154·2	30·9	456·8

AMERICAN ARMY IN TIME OF WAR (Hammond).

Kind of ration.	Daily.	Albuminoids.	Fats.	Carbohydrates.
	grms.	grms.	grms.	grms.
Bread or flour	625	53·0	5·5	313
Meat, fresh or salted	566	114·8	28·8	2·6
Potatoes	443	5·8	0·7	88
Rice	47	3·1	0·45	37·6
Beans	85	20·0	1·27	51·8
Coffee	47	—	—	—
Tea	7	—	—	—
Sugar	60	—	—	60
Vinegar	42	—	—	—
Salt	21	—	—	—
Pepper	9	—	—	—
		196·7	36·7	553

We collect all these data in the following table by adding together those furnished by different authors for the alimentation of workmen submitted to fatiguing work from eight to twelve hours a day.

RATIONS FOR FATIGUING WORK.

	Albuminoids.	Fats.	Carbohydrates	Calories theoretically calculated.	Authors.
	grms.	grms.	grms.	Cals.	
French workman pumping (South of France)	156·5	85	709	4218	A. Gautier
Agricultural labourer in the South of France	149	79·1	829·7	4560	„
Railway labourer (Rouen) .	174·6	84·1	716	4304	De Gasparin
Labourer of the Dépt. du Nord	177·1	122·5	1022·5	5874	„
Agricultural labourers (Canton of Vaud)	160	91·7	713·7	4274	„
German wood cutter . . .	135	108	876	4664	J. Liebig
German farm labourer of Laufzorn (average)	143	108	788	4696	Ranke
English labourer	184	71	570	3655	Smith and Playfair
Labouring families (U.S.A.) .	97	130	467·0	3415	Atwater
English blacksmith . . .	176	71	666	4007	Playfair
French soldier in time of war .	137	18·8	632	3247	(Regulations)
French sailor during campaign	155·5	40·7	591	3338	„
Prussian soldier, large war ration	183	33·7	624	3534	„
American army in time of war	196·7	36·7	553	3327	„
English soldier in time of war .	154	30·9	457	—	„
Military workers (Chatou) .	160	66	580	3554	Smith and Playfair
Gangs of American boatmen .	155	177	440	3955	Atwater
Artisans (American) . . .	103	150	402	3365	„
Workers in the big towns of the Union	101	116	344	2810	„
Averages	152	85	630	3884	
Weight per 100 of albumin .	100	44]	425	—	

The figures quoted in the preceding table are almost all averages relative to the food of the most diverse workmen as to country, climate and habits, of such a kind that the general average which results from the whole of these data translates with great probable nearness the alimentary necessities of the workman submitted to fatiguing work, without being excessive, and in conditions where the subjects under observation have not been able to make an abuse of excess of provisions or to waste them.

Calculated in *utilizable* calories, this average of working alimentation corresponds, for twenty-four hours, to the following number :

For albuminoids	152 × 3·68 =	559 Cals.
For fats	85 × 8·65 =	735 „
For carbo-hydrates	630 × 3·88 =	2444 „
Total	=	3,738 Cals.

Workmen occupied in very rough work (carpenters, woodcutters, blacksmiths, quarrymen, miners, navvies, etc.) especially

those who live in a very cold climate, need a still more substantial nourishment. I give here some examples borrowed especially from Smolensky:

NECESSARY RATIONS FOR FATIGUING WORK.

Professions.	Weight of nourishment	Containing per day.			Energy calculated in Calories.	Authors.
		Albuminoids.	Fats.	Carbohydrates		
	grms.	grms.	grms.	grms.	Cals.	
Sawers of wood at Astrakan .	1587	210·6	92·6	867	5105	Soudekow
Astrakan carpenters . . .	1944	144·1	72·8	693	3998	,,
Quarrymen, navvies, stone cutters of the Port of Cronstadt	2712	220	95	931	5429	Ivanov
Tomsk miners	2163	265·5	60·3	985	5591	Routovsky
Novgorod agricultural labourers	2233	151·5	56·5	798	4296	Griaznov
Swedish joiners and carpenters (laborious work)	4596	188·6	110·1	714·4	4590	Siven
German wood cutter . . .	—	135	208	876	5794	J. Liebig
Brickmakers of Munich (Italians)	1178	167	117	675	4409	Ranke
Austrian agricultural labourers (full work)	1493	181·9	93·3	967·7	5420	Ohlmüller
Boston carmen and carriers (work very laborious)	—	254	363	826	7535	Atwater
Bicyclists racing at New York.	—	186·5	185·4	584·6	4730	,,
American footballers . . .	—	226	354	634	6590	,,
Averages		191·3	132·2	810·8	5290	

The average ration for fatiguing work corresponds then to a disposability of about 3,800 Calories; for exceptionally severe work to 5,000 utilizable Calories.

The question of race seems to have far less influence on alimentary necessities than one might have thought, especially if these races, differing greatly but living in the same surroundings and climate, have the same facilities for obtaining their food. Here are a few statistics taken from Atwater's researches:

	Albuminoids.	Fats.	Carbohydrates	Theoretical Calories
	grms.	grms.	grms.	Cals.
5 French Canadian families living in Chicago .	118	158	345	3200
4 Italian families living in Chicago	103	111	391	2965
8 Bohemian families living in Chicago . . .	115	101	360	2800
10 Russian Jews living in Chicago	137	103	418	3135
A family of Chinese farm labourers, California	144	95	640	3980
20 Negro families, Alabama	62	132	436	3165
19 Negro families, Virginia	109	159	444	3625
	112	122	433	3267

Thus, these workmen of very different races doing a relatively moderate amount of work, disposed of an alimentation which furnished them with an almost unvarying sum of Calories; whereas an European workman, under the same conditions, furnishes about 3,200 or 3,300 Calories daily.

Following the facts in the preceding table and those on p. 84 we admit that an adult should, according to his work, dispose of an alimentation which furnishes him with the following quantities of energy, expressed in Calories:

	Real Calories.[1]		Calories corresponding to a kilogrm. of body weight.
	Rübner.	Atwater.	
Complete repose	1880–1900	—	28–30
Relative repose (exercise very moderate)	2200–2400	—	35–38
Moderate work	2445–2868	2450–3050	38–45
Fatiguing work	3300–3800	3400–3800	45–55
Very fatiguing work . . .	4150–5300		58–75

If from the ration of the workman, such as we have described (p. 94), we deduct that of the same workman at rest (p. 85), we shall have the surplus ration necessitated by the production of mechanical labour:

	Albuminoids.	Fats.	Carbo-hydrates.
	grms.	grms.	grms.
Workman at work	152	85	630
Workman at rest	78	50	388
Excess of alimentary principles necessary for work	74	35	242

We have seen earlier how, and under what different forms, this excess of assimilable principles could be provided by the aliments.

Such as it is, this average excess of assimilable elements which work causes to be additionally consumed, corresponds to a number of Calories easy to determine:

For 74 grms. of albuminoids	296	Cals.
For 39 grms. of fat	311	,,
For 279 grms. of carbo-hydrates	968	,,
Total	1,575	Cals.

[1] Calories deducted from the theoretic coefficients and multiplied by the relation 91/100 found between the theoretical and the real yield of energy in the case of mixed rations.

The difference found by Atwater between the energy measured by the calorimeter in the form of heat set free by man in repose, and that corresponding to the losses of the same individual employed in fatiguing but not excessive work, is 1,400 Calories. These 1,400 Calories correspond theoretically to 597,125 kilogrammetres.

We have said that a very good workman produces in mechanical work, in a day of ten hours, 170,000 kilogrammetres of *useful work*; from which it follows that 28·0 per cent. of the energy of *the supplementary ration* of work is utilized by good workmen to directly produce motive force.

In a state of relative repose, of the 2,350 Calories which he disposes of, thanks to his ration of maintenance, the average man loses the following, calculated according to the number above and the observations of Atwater and Benedict :[1]

49·35 Cals. or 2·1 per cent. of total energy transformed into exterior works of maintenance, frictions, involuntary movements, work of the respiratory muscles.

1,694·45 Cals. or 72·1 per cent. corresponding to the caloric radiation of the body, to the loss of heat by conduction as well as by the warming of the air leaving the lungs.

573·30 Cals. or 24·4 per cent. for the latent heat of the vaporization of water through the lungs and skin.

32·2 Cals. or 1·4 per cent. for heat carried away by the fæces and urine.

In *a state of work*, the 2,350 + 1,400 = 3,750 *utilizable* Calories, on an average are divided into the following proportions, still keeping for our bases the observations of Atwater and Benedict (*loc. cit.*) :

75 Cals. being 2 per cent. for heat corresponding to slight unconscious movements, necessary displacements of the body and of its centre of gravity, frictions, respiratory movements.

2,262 Cals. being 60·3 per cent. for heat radiated by the skin, and heating of the gases of the air leaving the lungs.

1,155 Cals. being 30·8 per cent. for heat corresponding to evaporation of water from the lungs or lost by perspiration.

[1] Atwater and Benedict have given (*Experiments on the Metabolism*, p. 141, Washington, 1902) the following experimental mean numbers :

	State of Repose. Per cent.	State of Work. Per cent.
Heat radiated by the body, heat lost by conduction and by heating of the surrounding air	74	62·3
Latent heat of vaporization of perspired or expired water	24·4	30·8
Heating of the urine and fæces	1·4	0·5
Heat equivalent to muscular work recorded by the ergometer	0·0	6·4

It is to be noticed that in this calculation all external work counts for nothing in the state of rest, which is only true of absolute rest. Really we ought to reckon as being absent in rest, from the radiated heat, the heat equivalent to the movements and work of the respiratory muscles, and all the work necessitated by the functioning of the human organism which is only in a state of relative rest.

18 Cals. being 0·5 per cent. for heat lost by the fæces and urine.
240 Cals. being 6·4 per cent. for heat corresponding to work collected by the ergometer.

These figures, especially the first and last, are somewhat uncertain. According to each individual, the percentage in energy corresponding to non-utilizable labours, frictions, respiration, or to what may be transformed into useful work, varies somewhat largely. It changes also with the nature of the work. These two numbers may then be greatly modified. However, the average found by Atwater and Benedict for the quantity of energy which can be transformed into registrable useful work, is a percentage of 6·4. The 240 Calories that the subjects observed by these two American professors transformed into useful work, corresponded to 102,000 kilogrammetres only. But, I have proved, as I have just said, that a good workman pumping can produce 150,000 kilogrammetres of useful work in eight hours, and Frankland has obtained as much as 180,000 kilogrammetres. These figures are in the same proportion; but they clearly show that the amount of useful work obtained by scientists, shut up in Atwater's and Benedict's calorimetric room, is far below the average furnished by a man working in the open air. In reality a good workman can transform into *useful work* nearly 10 per cent. of the total energy of his foods.

By comparing the averages obtained by the same subjects in repose and at work, we can draw the following conclusions from Atwater's numbers.

During work man radiates by the skin a much smaller fraction of heat than in a state of repose (60·3 per cent. at work instead of 72 per cent. at rest), but the amount of absolute heat radiated during work is increased in about the same proportion as that which is lost by this process in a state of repose; of 2,262 − 1,694 = 568 Calories in the above case.

Whereas in a state of repose, the heat lost by cutaneous evaporation and respiration was 573 Calories in Atwater's example recorded earlier, in the working state, it is raised to 1,155 Calories, being 582 Calories more. This cutaneous evaporation, which thus causes 582 Calories to disappear, is employed to keep the temperature of the body which tends to rise during work owing to excessive combustion, constant.

Finally, 240 + 15 Calories are transformed into utilizable work.

The employment of the additional 1,405 Calories necessitated by the work in the example above is as follows:

Excess of radiation from the body . . .	568 Cals.
Excess of cutaneous and pulmonary evaporation .	582 ,,
Real work in Calories	255 ,,
	1,405 Cals.

In these experiments, out of the overplus of 1,405 alimentary Calories (or corresponding energy) necessitated by work, 255 Calories only, or a little more than 18 per cent., are transformed into work, but, as we have already said, this proportion may rise to 25 or even 30 per cent. in the case of very good workmen.

Do organisms exist more capable than others of transforming into work a larger proportion of alimentary energy ? Are these aliments or stimulants capable of increasing the yield in work and of making a greater part of the energy, lost by evaporation or by radiation from the body, transform itself into work ? It seems likely that it is so. Certain races of animals and men, when working, utilize to greater advantage than others the same alimentary ration. Certain stimulants can augment, as we shall see, the yield in work. It seems that alimentary principles which produce by their combustion less water and consequently less cutaneous evaporation and radiation, assure a higher yield in work. The albuminoid matters transforming themselves in the system into urea, etc., give, for a like number of Calories produced, less water than the fatty and hydro-carbonated principles, it is a fact that they are more favourable to work, either directly or by stimulating the nerve centres. They seem also more capable of assisting the muscle to rapidly renew itself when it is wearing itself out : W. Edwards has proved by the dynamometer, that after a very rich meal of meat, his strength was increased much more than after a meal calorimetrically equivalent, but where vegetable substances predominated. In fact, people who eat much meat produce much work and are fit for all sportive exercises, and it has been practically observed that workmen, agricultural labourers or artisans, produce more work if, in their habitual ration, they replace a part of the hydro-carbonated or fatty foods by nitrogenous foods of equivalent energetic value, but without this substitution exceeding nevertheless a certain limit.

Besides it remains proved to-day that muscular work *sensibly* increases the production of urea, and, in general, the dissimilation of extractive nitrogenous matters, although, in a measure, much inferior to those indicated by the calculation if the work performed had resulted entirely from the destruction or combustion of proteid bodies. One often quotes the experiments of Pettenkoffer and Voit apparently showing that, by a *mixed diet*, the elimination of urine and destruction of albumin are not sensibly increased by work, when it considerably increases the destruction of fats :

In 24 hours.	At Rest.	At Work.
Urea	37·2 grms.–36·3 grms.	36·3 grms.
Albumin disappeared. .	137 grms.	137 „
Fat disappeared . . .	315 „	323 „

But one will notice that, in these experiments, the individual under observation was superabundantly fed, and that already he was destroying, in a *state of repose*, a quantity of nitrogenous and fat elements more than sufficient to provide for his work; the superabundant quantity of ternary materials in reserve protected him therefore against an excess of dissimilation of albumin.

Besides, nothing could prevail against this observation that everywhere the workman who works, eats, if he can, more meat than when he is unemployed and that, consequently, ceasing to assimilate this albumin, he must furnish an excess of urea, if not proportional to the excess of nitrogenous foods, at least parallel to it.

On the other hand, in hot or cold climates, the workman invariably augments his ration, particularly and instinctively by starchy substances and above all by fats which are the principles whose combustion is most qualified to furnish energy capable of being transformed into mechanical force: in spite of this, meat still remains the chief stimulant and regenerator of muscle. I say meat because experience has shown that it is not immaterial to provide for those who do arduous work, beef, fish, or plenty of bread and vegetables, containing like quantities of albuminoid principles. These principles, when they are of vegetable origin, are only assimilable in the proportion of 83 per cent., when 96 per cent. reach the blood if they come from meat. Further, albumin of plants can only be utilized after a more difficult and slower task of assimilation than when it is a question of animal albuminoids. Above all, it does not bring with it the nerve excitant, these alkaloids of muscular flesh, which neither gluten nor legumin would be able to provide us with.

This is not the time to demonstrate what are the correct stimulants to hasten muscular action and to improve its produce. It is a very interesting question which we propose to study in detail in its place and which ought to be decided in the affirmative. (See "Aromatic Condiments and Spirituous Beverages.")

It is necessary for man, when working, to dispose of the excess of combustible heat that work creates whilst only losing a small portion of it. His drink furnishes him with water which, by means of pulmonary and cutaneous evaporation, refreshes the blood and the tissues, provided however that this water is eliminated by the lungs and skin instead of by the kidneys.[1]

[1] Weyrich, quoted by Ch. Richet (*Dict. of Physiolog.*, article on "Heat" has found:

	Quantity of sweat per hour in grms.	Cals. corresponding to the evaporation of this sweat.
Moderate movements in the room	7·6 grms.	4·065 Cals.
Violent ,, ,, ,,	7·6 ,,	4·065 ,,
Moderate ,, ,, sun.	21·8 ,,	11·728 ,,
Violent ,, ,, ,,	28·3 ,,	15·225 ,,

Atwater in his experiments has found the same results. According to him, man doing an average amount of work—eight hours a day—absorbs about half as much food as he would require in a state of repose. He prevents his organs from becoming overheated, not only by eliminating through the skin the excess of water that he consumes, but also a part of that which, in a state of repose, would pass through the kidneys. With regard to this, I give here some very instructive average numbers taken from Atwater's experiments :

	Water per 24 hours.[1]		
	Patient E. O.	Patient J. F. S.	Averages.
A. In repose.			
1. Water received by foods . . .	1037 grms.	1055 grms.	—
,, ,, drinks . .	1407 ,,	833 ,,	—
Total water	2444 grms.	1888 grms.	2166 grms.
2. Water eliminated by the fæces. .	59 grms.	52 grms.	—
,, ,, ,, urine .	1810 ,,	1219 ,,	1515 grms.
,, ,, ,, expiration and perspiration	977 ,,	830 ,,	903 ,,
Total water	2846 grms.	2101 grms.	2473 grms.
B. In work.			
1. Water received by the foods .	1168 grms.	975 grms.	—
,, ,, ,, drinks .	1603 ,,	1250 ,,	—
Total water	2771 grms.	2225 grms.	2498 grms.
2. Water eliminated by the fæces . .	96 grms.	52 grms.	—
,, ,, ,, urine . .	1011 ,,	905 ,,	—
,, ,, ,, respiration and perspiration	2275 ,,	1670 ,,	1972 grms.
Total	3382 grms.	2627 grms.	3005 grms.

We see that in the working state, these two subjects have eliminated 522 grms. more water than in the state of repose, and that this water, far from being found in greater quantity in the urine emitted during the working period, is less (an average of 357 grms. less water in the urine) and that the quantity expired and perspired augments to 1,069 grms.

[1] Average weight of patients : 68·5 kgs.

X

NUTRITION—THE CELLULAR MECHANISM OF ASSIMILATION AND OF THE PRODUCTION OF VITAL ENERGY

ALIMENTATION is but the first stage in the process of nutrition. It furnishes the plastic material which, successively modified by the intestinal ferments and finally by the assimilative digestion of the tissues, is continually repairing the loss which the vital functions necessarily create. The general life of the individual is maintained by the regular co-ordination of functional processes. These elementary processes, the succession and order of which alone appear to be in correlation with the structure of nervous tissue, and, in each cell, with that of its presiding nucleus, are themselves purely physico-chemical or mechanical reactions, which in their turn derive from the molecular structure, from the *chemical constitution* and from the essential principles of which each of the cells of the organism is built up.

Before passing to the study of foods and diet, in order to terminate *Part I* given up to the statement of *Principles*, I should like to show how nutrition, the working of the functions of the general life, is regulated by the inmost phenomena of assimilation and disintegration, which take place in the cell or in the tissues. Also how the normal development of the functions as well as the abnormal habits, peculiar constitutions, and later distinctly morbid states, are allied with primitive molecular chemical phenomena, all those, at least, which spring from irregular feeding or vicious nutrition of the organs.

Mechanism of Nutrition.

We know that the constituent cells of each of our tissues are essentially formed of phosphorated proteid matters : *cytoproteids* in the protoplasms, *nucleoproteids* in the cellular nuclei. These proteids are distinctive in each kind of cell. They are generally associated there with other simpler non-phosphorated albuminous substances, and with still simpler forms (hexoses, lecithins, amine-acids, fats, glycogen, etc.) which appear to be derived from the simplified divisions of the *cytoproteids* and *nucleoproteids* and perhaps, in the case of some at least, to have been brought directly by the blood and stored in the cell.

During the process, three complementary phenomena take place in succession : 1. The disintegration of the most complex and most unstable proteids which, by virtue of this same instability, appears to start other chemical actions. 2. Inversely, the continual reproduction of these essential molecular organs of the cell which is due to the phenomenon of assimilation. 3. Finally, the utilization of the albuminoids or ternary reserves which, in hydrating, decomposing, and becoming oxidized, etc., furnish the greater part of the energy which the cell uses up in functioning. All these processes in the life of the tissue are dependent on specific agents, that is to say, *the ferments*, of which we will now speak.

Ferments.—These agents of the primary vital functions seem to be intended, some to pour into specific molecular moulds the surrounding matter which has been previously split up ; others to divide the nutritive material brought by the circulation into simpler assimilable parts by forming unstable combinations with them and which are eventually decomposed by water. Others, again, give to the surrounding matter the nascent oxygen or hydrogen with which they are momentarily charged under the form of dissociable peroxides or hydrurets, etc. These agents of molecular transformation, the promoters of assimilation, hydrations, oxidations, reductions and decompositions, etc., play an immense part in regulating, furthering and retarding the process of digestion. We shall try here to characterize their nature and the part they play.

When the primary albuminoid substances of plants and animals undergo gastric digestion, they become peptonized by the action of stomachic ferments : their complex molecules divide into simpler albuminoids by means of hydrolysis or molecular intussusception of water. When it is a question of the phosphorated proteids, of the plasmas and cellular nuclei, digestion separates, on the one hand, the nucleins which carry off all the phosphorus, and on the other the propeptons and peptons, bodies still of a proteid nature, but of less molecular weight and simpler formation than those of the nucleo-proteids or cyto-proteids from which they are derived.

These new albuminoid bodies as well as the other grades of this first phosphorated division, the nucleins, penetrate into the duodenum and there undergo the action of fresh intestinal ferments such as trypsin, erepsin, etc. The result of this action is to simplify more and more, and always by successive hydrolysis, the albuminoid compounds which they succeed in transforming thus into a series of amino acids (alanin, leucin, glycocol, serin, tyrosin, etc.). We know to-day that the other class of the primary division of the cyto-and nucleo-proteids, the nucleins, are divided into phosphorated compounds (*thymic acids*) and

albumoses, compounds which pass into the circulatory system after having undergone the action of the ferments contained in the glands of the intestinal walls and in the lymphatic globules. In this way the proteid molecules which, in the cell, first constitute the complex phosphorated albuminoids of the primary protoplasm and of the nucleus, are successively divided and subdivided by means of these digestive ferments which hydrolyze and divide, into less and less complicated molecules which the blood carries pell-mell to the various organs. Through the dissolving action of the digestive or dissimilating ferments and by virtue of the very functioning of the cell, the proteids of the nucleus and those of the plasma of the cell which has functioned, have lost a part of their substance, phosphorated, thymic combination, xanthic or pyrimidic bases, sugars, etc., which help to constitute in a perfect state the primitive essential proteids. But the cellular or molecular mould remains after the accessory parts have disappeared, and it tends to complete itself by means of the materials or analogous or identical couples which are brought to them by the blood enriched by digestion. Thus, the specific complete molecule forms itself anew, the remaining part of the organic construction involves and controls the disposition of the complement which has just nourished it.

Assimilation then appears to us to be the result of a kind of continuous reproduction of these essential primary proteid molecules of the plasma and cellular nuclei, the specific forms of which would have been partially preserved owing to the greater stability of some of their parts. These latter would develop, owing to the surrounding nutritive medium, by extracting from it those materials which have sprung from the digestive divisions which, owing to their form, can repair the waste produced in the primitive proteid molecules of the cell: losses due to the partial destruction of the molecule which has performed its function. For, just as the entire cell reproduces itself in its primitive form when it has been injured, and as it repairs little by little the waste caused by the loss of substance or vital dissimilation, so one can understand the behaviour of the chemical integrant essential molecules of the nucleus and protoplasm. And if the free cells of yeast, the bacteria, the protozoa which possess the property of being able to nourish themselves and complete their substance by appropriating for themselves the surrounding matter which they disconnect, transform and continually assimilate; and if these same bacteria and yeast are named "figured ferments," in the same way we can give the title of *ferments and ferments of proteid assimilation* to those particular molecules of cytoplasma or of nucleoplasma which are able to reproduce continually their own substance at the expense of the surrounding material parts which they modify and assimilate in order to complete themselves.

We know that the complex proteid matter in the intestine submitted to the action of the ferments of hydrolysis or disintegration, divides itself into simpler parts. The same phenomena attend the divisions which take place in the cell. It possesses also dissimilating ferments. They appear to be contained there in the form of granules, which under the microscope have a similar appearance, but their specific nature is easily recognized owing to their different effects. We have been able to extract simultaneously from a common body, *aspergillus niger*, the following: a *rennet* able to coagulate caseine; a *casease* which liquefies and digests this coagulum; a *lipase* suitable for splitting up the fats into glucose and fatty acids; a *sucrase* able to transform, by hydration, the saccharose into glucose and levulose; an *amylase* and *maltase* liquefying the starch and changing it into soluble sugar, etc. (Duclaux, Gérard, Bourquelot). Now, that which has been observed concerning this common organism, applies to nearly all vegetable or animal cells. From the latter especially, we can always extract one or several proteolytic ferments which are capable of transforming the albuminoids, after the manner of trypsin, into relatively simple amine molecules: leucin, glycocol, glutamic acid, tyrosin, etc., products of more or less advanced disintegration, all resulting from the hydrolysis of the proteid molecule while functioning: and all formed by the transformation of a part of the virtual energy of the molecules into utilizable energy which the cell uses in furthering the life process.

Like the ferments of protoplasmic assimilation, these ferments of dissimilation appear also to be essentially formed by the radicals or parts derived from the primitive albuminoid molecules. These radicals or soluble ferments preserve their specific molecular structure, a structure qualified to adapt itself to that of certain materials upon which henceforth they can operate, undoubtedly in virtue of the unstable combinations which belong to the very nature of these external forms. Reciprocally, those of the diastases which adapt themselves the best to the food which is offered to their activity, are also those which detach themselves easiest from the molecule which carries them and which appear in a greater quantity in the surrounding nutritive liquid. Thus, we perceive that the nature of these soluble ferments varies according to the food: *aspergillus niger* cultivated on glycerine or upon the starch of fecules, secretes chiefly *amylase*; in milk it produces rennet and casease; in solution with lactate of lime, it furnishes sucrase with neither amylase, rennet nor casease. Likewise by a similar mechanism, emulsions of fresh liver or kidney injected into an animal of a different species produce little by little in its blood a hepatolysin or a nephrolysin which have the power of destroying the proteids of the liver or

kidneys of animals belonging to the same species as those which furnished the stimulating agents of these specific secretions.

Several of these ferments play reversible parts : they appear to operate until a certain equilibrium has been obtained between the fermentable materials and the products which are formed, the equilibrium being re-established if the limit comes to be passed. Thus, according to Croft Hill, maltase which transforms maltose into glucose can, by acting on a somewhat concentrated solution of glucose produce, not precisely maltose, but an isomeric body very similar to it, namely isomaltose. According to Poitevin, the lipase of the pancreas would reproduce olein in the presence of a mixture of oleic acid and glycerin.[1]

E. Fischer and Armstrong have established that the diastase of kephir grains unites the glucose to the galactose in order to reproduce the isolactose which the kephir in weaker solutions splits up into glucose and galactose. But we perceive *à priori*, that the diastatic actions which are accompanied by little or no escape of heat, should alone be reversible. This fact assures me that the pure stomachic peptons, in somewhat concentrate or diluted solutions, cannot change into propepsines or albumins under the action of an excessive or feeble proportion of very active pepsin.

We shall terminate our observations concerning soluble ferments by remarking that they frequently supplement and mutually aid one another. Pawlow has established that pure pancreatic juice does not digest the albuminous substances but that, on the contrary, it dissolves them actively after the addition of a few drops of a chilled intestinal infusion. This activity which excites the juice of the glands of the intestinal mucous membrane, and which disappears like nearly all diastases when the infusion of the glands is brought up to 80° or 100,° is due to a stimulating or complementary ferment of trypsin, the *enterokynase* which can be extracted from the mucous membrane of the intestine.

This stimulating or complementary action of a ferment secreted by one cell on the ferment or on the operation of a cell of a different nature, appears to be a general phenomenon. It is thus that the internal secretions of the thyroid, suprarenal, testicular, ovarian glands, etc., act on nutrition, either by stimulating directly the life of certain tissues, or by exciting the secretion of their ferments, or by completing the action of the latter as is the case with the *erepsin* of O. Conheim, which is able to transform the intestinal pepsins and propepsins formed by the trypsin and enterokynase into amino acids, while the erepsin alone is incapable of directly influencing the primary albuminoids.

[1] Poitevin, *C. Rend.* t. CXXXVI, p. 1,152.

After having explained the idea which we have formed of these mysterious ferments which preside over general assimilation and dissimilation, I shall only briefly indicate the principal kinds.

Ferments of Assimilation.—We have previously stated (p. 104) the manner in which we conceive that they work in the protoplasms.

Ferments of Hydrolysis and Dehydration.—*The ferments of hydrolysis* are those which, by the intromission of water, promote the divisions which take place in the midst of the cellular protoplasms. Thus in every animal cell, there exist real trypsins which digest and hydrolyze the albuminoids in a slightly alkaline medium. Likewise we find albuminoids in nearly all the products of digestion, peptons, propeptons, amine acids, etc. In the vegetable kingdom the starches, sucrases, maltases, lipases, etc., which hydrate the starches, sugar, maltose, fats, etc., are the well known representatives of these diastases most often with a reversible action. As regards the hydrolyzing fermentations of albuminoid substances, I have already stated that they do not appear to me to be capable of reversing their action.

It is owing to the phenomena of hydration taking place in the proteid molecules of the cytoplasmas that the latter, *protected from all direct oxidation*, are split up into globulins, albumoses, protamines, etc., and phosphoric cyteins. This second state, which contains all the phosphorus of the molecule, is capable of dividing itself by fresh hydrolysis into pyrimidic bases (*thymin, uracile,* etc.) into hexoses and phosphoric acid. The nucleoproteids or proteids of the cellular nucleus also divide themselves, by hydrolysis, into these same derivatives, but with the addition of the puric bases (guanin, sarcin, adenin, etc.) as intermediaries. It will be observed that all these derivatives, sugars, pyrimidic bases, puric bodies, with uric acid, etc., and urea itself which can be derived from them by simple hydrolytic reaction, all these bodies are formed without the intervention of the exterior oxygen.

Oxidizing and Reducing Ferments.—Among these we include the oxydases of Schmiedeberg and Jacquet. In animals the principle appears to be found almost entirely concentrated in the white corpuscles.[1]

We find again an oxidizing ferment in the lacto-plasma, another in the hemolymph of the crustacea. The oxydo-reducing ferments of the liver, kidneys and other organs change easily, while oxidizing, the salicylic aldehyde into salicylic acid (*Abelous and Biarnez*). That which MM. Abelous and Ribaut have extracted from the liver combines the glycocol with benzylic alcohol which it oxidizes yielding

[1] Portier, thesis for the Doctor of Science degree of Paris 1897. *Oxydases in the Animal Series,* p. 84.

hippuric acid. The laccase of the lac-tree (*Hikorokuro Yosida*; *G. Bertrand*), the tyrosinase of mushrooms (*Bourquelot*) are oxidizing ferments extracted from vegetables.

A somewhat unexpected feature attributable to the tendency of ferments to frequently exercise inverse action, the oxydases of the tissues, especially those of the liver, possess at the same time a reducing or hydrogenizing power proportional to their oxidizing activity (*Gérard, Abelous, and Aloy*).[1] They act as if, decomposing the surrounding or combined water, they convey the hydrogen on one molecule, or part of a molecule, and the oxygen on another. The liver and kidneys are the most charged with this singular ferment, the muscles and the brain the least.

The researches undertaken in my laboratory by Dr. Helier in order to measure the reducing power of the tissues and liquids of the system[2] establish that, of all the media, *lymph and the arterial blood* are the most *reducing*; then come venous blood, muscles, pancreas, kidneys, lung and spleen. The blood becomes especially *charged with reducing products at the moment of digestion* without it being possible to attribute this effect to a fermentative hydrogenating action. But is it possible to produce a more convincing proof of the necessity of the oxydases for promoting the oxidations of the system, than to see the cells irrigated by an essentially reducing blood?[3]

Ferments of Decompositions and of Re-composition.—The first of these was extracted in 1896 by Büchner from the yeast of fresh beer. When it is compressed to 500 atmospheres, a liquid proceeds from its cells which, mixed with a solution of slightly concentrated glucose (15 to 20 per cent.), immediately changes this body into alcohol and carbonic acid, exactly as the living yeast would do.

Stoklasa and Cerny, in 1901, extracted[4] a similar ferment from animal tissues which also changed glucose into alcohol and carbonic acid:

$$C^6H^{12}O^6 = 2CO^2 + 2C^2H^6O.$$

They have found in human tissues another soluble ferment which divides the glucose into two molecules of lactic acid.

These are the dissimilating ferments by decompositions.

Coagulating and Liquefying Ferments.—The *fibrine ferment* which changes fibrinogen into fibrine; *thrombin* which coagulates all the plasmas of animal cells; *rennet* which curdles the casein of

[1] *C. R.*, t. CXXX, p. 426; t. CXXXIV, p. 479; t. CXXXVII.

[2] *C. R.*, t. CXXVIII. p. 319 and 687.

[3] Helier measured this power by reduction of permanganate. The action of the tissues might have been very different in the case of another reagent.

[4] See M. Bourquelot's articles in the *Journ. de Pharmacie*, sixth series, t. IV, p. 241, 440 and t. V, p. 8.

milk; and in the vegetable kingdom, *pectine* which coagulates certain juices of fruits, are all examples of coagulating ferments. On the contrary, *casease* which redissolves the curdled casein the *antithrombines*, etc., are decoagulating ferments, as in the case of vegetables, it is *cytase* which liquefies the envelope of the cells.

All these ferments serve either to transmit the plastic or nutritive matter in soluble forms where it can circulate and later be oxidized or, on the contrary, polymerize, coagulate and render it insoluble, in order to store it, until the system has recourse to the reserves thus formed for the maintenance of the cellular life or the general functions.

Products of Dissimilation.—It is now possible to rapidly examine the effects of this dissimilation of the primary albuminoid matter, or of that of the reserves stored in each cell, a dissimilation the working of which we have just studied. By entire disintegration in warm blooded animals, 100 grms. of albumin could theoretically produce 165·4 grms. of carbonic acid; 41·4 grms. of water; 39 grms. of urea; 4·25 grms. of sulphuric acid, while absorbing at the same time 148 grms. of oxygen taken from the air, thereby adding 486 Calories to the body. But, as a matter of fact, the total nitrogen is not found again in the urea produced, and the percentage proportion which is formed from it depends upon the state of the patient's organism and on his manner of feeding. In the case of the man of normal health, feeding on a mixed diet, 100 parts of nitrogen leave the system by urinary excretion as follows:

In the form of urea	83–87
„ „ ammoniacal salts	2–5·5
„ „ uric acid and xanthic bodies . .	1–3
„ „ other nitrogenous matters . . .	7–10
	100

Gumlich gives the following percentages:

	Mixed Diet.	Animal Diet.	Vegetable Diet.
Nitrogen			
In urea	82·9–87·3	79·2–88·2	76·9–83·4
In ammoniacal salts	3·8– 5·8	3·5– 5·6	3·4– 8·6
In other nitrogenous matters . .	8·0–11·9	7·5–17·2	10·5–17·6

In the normal state, almost the whole of the absorbed nitrogen is found again in the total liquid and solid excreta of the subject (hair of the body, hair of the head, epidermis, fæces).

Urea, uric acid, ammoniacal salts, generally combined with a small amount of nitrates, are the final products of nitrogenous dissimilation, and the numbers in the above tables give no information concerning the intermediary substances, nor the nature

of the *nitrogenous residues* known as *extractives* or *indeterminates*. It will be seen in *Part II*, under the study of *Regimens*, how very important these intermediaries are which, in the case of meat alimentation for example, produce an excess of nitrogenous substances in the system which have a tendency to acidify the blood, excite the heart, and intoxicate the subject, should there be the slightest disorder in the functions of the skin, lungs, liver or kidneys.

Among the best known intermediary nitrogenous products are the following: 1st, the *amino-acids* such as *glycocol*, $CH^2NH^2CO^2H$, and *taurine* $CH^2(NH^2)CH^2(SO^3H)$ which the liver normally secretes in the form of glycocholic and taurocholic acids, or the kidneys under the form of hippuric acid (benzoyl-glycocol). It is these which, like the ammoniacal salts and ammonia resulting from a more advanced hydration, passing through the liver, produce urea. Among the amine bodies the following must be quoted: Tyrosin or *paraoxyphenylamidopropionic* acid:

$$C^6H^4{<}\begin{matrix}CH^2 - CH(NH^2)CO^2H \\ OH\end{matrix}$$

a substance produced by hydrolytic decomposition of the greater part of the albuminoids; and in its turn, giving by the same process, alanine $CH^3CH(NH^2)CO^2H$, lactic acid and phenol; 2nd, *the creatinic bases*, especially the *creatin* of the muscles

$$NH = C{<}\begin{matrix}NH^2 \\ N(CH^3) - CH^2 - CO^2H\end{matrix};$$

the *creatinin of the urine*

$$NH = C{<}\begin{matrix}NH \\ N(CH^3)CH^2\end{matrix}{>}CO;$$

3rd, the *lysatin* and *arginin*, amines which are found in many of the glands: *spermin; neurin*

$$N\begin{cases}(CH^3)^3 \\ CH = CH^2OH\end{cases}$$

and *cholin*

$$N\begin{cases}(CH^3)^3 \\ C^2H^4OH \\ HO\end{cases}$$

very poisonous bases of the brain and bile. 4th, the bodies of the *pyrimidic series* (*Uracile* $C^4H^4N^2O^2$ [or 2·6 dioxypyrimidine]; *Cytosin* [or 2 oxy-6 aminopyrimidine], *thymine* [or 5 methyl-2·6 dioxy-pyrimidine]), rare bases, however, but necessary intermediaries of the decomposition of primary cellular proteids; 5th, the *puric bases* partly derived from the nucleo-proteids of the cellular nuclei of the system, and partly introduced by alimentation, amongst these are *xanthin* $C^5H^4N^4O^2$, *sarcin* $C^5H^4N^4O$, the *methyl* and *paraxanthins*, *adenin* $C^5H^5N^5$, *methylguanin*, etc., bases

found in most of the glands. According to Krüger and Salomon, 1,000 litres of urine would contain about 9 to 10 grms. of these bases.[1] Among these puric bodies, *uric acid* $C^5H^4N^4O^3$ is the most important. We eliminate by the urine 0·3 grms. to 0·5 grms. per day, but, with an entirely meat diet, the weight may increase up to 2 grms. per twenty-four hours. We shall learn the part this variable production of uric acid plays according to the régimes. 6th, it is necessary to add to these nitrogenous products of dissimilation *urochrome*, the normal pigment of the urine. It originates from the oxidation of a part of the colouring matter of the blood; *indoxylsulphuric acid* $C^8H^7NSO^4$ or $C^8H^6(SO^3H)ON$ which draws away with it a part of the constitutional sulphur of proteid substances. 7th, bases of the nature of ptomaines and some derivatives called nitrogenous extractives, sometimes not capable of dialysis, these latter being found extremely toxic, but in a very small proportion (0·130 grms. to 0·150 grms. per litre of normal urine).

It has been seen that the sulphur of the albuminoids is partly dissimilated in the form of indoxyl-sulphuric acid. It is found again among other products of cellular excretion: paracresol-sulphate of potassium (with a little ortho- and meta-cresolsulphates); sulphocyanhydric acid; neutral sulphurated bodies (trace of cystin, hyposulphites, taurin). The remainder of the oxidized sulphur of the albuminoids goes to saturate a part of the potash or of the soda of the tissues and the blood, and is ejected immediately in the form of mineral sulphates, by the urine which produces nearly 4 grms. per twenty-four hours.

The constituent phosphorus of the tissues or that of the foods, is found almost entirely fixed in the state of combined phosphoric acid, in the *nucleo-* and *cyto-proteids* of the cells; in the *protagon*, greatly resembling cyteins but possessing a neurinic and not a pyrimidinic or xanthic nucleus; in the *lecithins* which appear to be derived from this protagon and which unite again in their molecule, the phosphoric acid, cholin, glycerin and fatty acids in consequence of a kind of etherification. A small part of the phosphorus of the foods or tissues (1 to 2 per cent. of the total phosphorus) is eliminated by the urine in the form of neutral products of which little is known; the rest is rejected in the form of phosphates of which the urine produces nearly 3 grms. per day. Nearly one-third of this mineral phosphorus is in the form of alkaline earthy phosphates and two-thirds in the forms of alkaline phosphates.

Concerning the dissimilation of ternary bodies, amongst the urinary losses of an aromatic nature, I shall only quote: the

[1] Xanthin, 1·01 grms.; heteroxanthin, 2·23 grms.; methylxanthin, 3·13 grms.; paraxanthin, 1·53 grms.; sarcin, 0·85 grms.; adenin, 0·35 grms.; epiguanin, 0·34 grms.

phenols, scatols, benzoic acid obtained by decomposition of the tyrosins; *cholesterins* which seem to have originally come from particular albuminoids of the blood corpuscles, from nervous tissue and from the protoplasm of young vegetable cells; *cerebrins*, etc. Among the non-aromatic ternary products it is necessary to place before all others, sugars (*glucose*; *inosit* $C^6H^{12}O^6$), *glycogen* $(C^6H^{10}O^5)^n$, neutral fat bodies, and lastly fatty acids themselves (*oleic*, *margaric*, *stearic*, *butyric acids*). All these bodies appear capable of production from the direct or indirect division of albuminoids, with or without loss of carbonic acid. Under the influence of saponifying ferments, the fats produce glycerin, which is wholly or partially destroyed, and fatty acids, which, by combining with the alkalies of the blood, are oxidized by degrees until they are entirely transformed into carbonic acid and water, thus benefiting the system by an enormous amount of latent energy set free by this combustion. Heat thus produced represents nearly 85 per cent. of the total disposable energy. Among the other non-nitrogenous waste products of the system, are the lactic acids which are found in many glands and in the muscular juices; oxybutyric acids which are sometimes found in the urine, and above all the acids in $C^nH^{2n-2}O^4$ (oxalic acid $C^2H^2O^4$, succinic acid $C^4H^6O^4$).

A part of these last mentioned acids is introduced into the system directly in the foods, another proceeds from the dissimilation of the albuminoids and is produced in the normal state in our tissues. We eliminate every day 0·002 grms. to 0·010 grms. of oxalic acid by the urine. In good health, the greater part of that which is formed transiently is destroyed in the organism, that which is introduced with the foods undergoes combustion like that resulting from the oxidation of fats and sugars or from the hydrolysis of proteid bodies (*Albahary*). We shall revert to this point *à propos* of *régimes* and oxaluria.

Besides the poisonous properties of the oxybutyric and oxalic acids (when under the influence of abnormal conditions of nutrition these bodies are produced in too great a number), they have a tendency to acidify the humours and to check the influence of the oxidizing ferments which could only operate in sufficiently alkaline media. This causes a marked state of acidity which is the origin of arthritis and a number of maladies said to be caused by retardation of nutrition.

Origins of Vital Energy.—It has been shown in the preceding chapters that the *actual* quantity of energy which the ordinary amount of nourishment puts at the disposal of the average man in our own climates, is from 2,350 to 2,400 realizable Calories which can be measured in the calorimetric chamber. It is interesting to discover by what process this energy, virtually existing in food, passes into the organs of the system in a real

and tangible form. We have seen that the nutritive principles assimilated or deposited in the cell are afterwards transformed by a series of reactions which simplify them and which determine the ferments: hydrations, decompositions, oxidations, etc. The life of the cell and of the whole body arises from the transformations of this energy which from virtual becomes actual, whilst promoting the functions of the organs.

Lavoisier was of the opinion that all heat proceeded from intraorganic combustion. R. Meyer discovered in 1842[1] that animal force and animal heat had the same origin and that they could both reciprocally transform themselves in equivalent quantities. But Lavoisier's opinion that the origin of this energy should have been looked for exclusively in the combustions of the oxidizable principles of the system, was for a long time maintained. However, in 1866, M. Berthelot pointed out that a part of this heat may certainly be attributed to a series of hydrations and fermentative decompositions. Our organs are essentially formed of albuminous matter which, by hydration, produces amino-acids; in course of this transformation, these albuminoid molecules absorb nearly as many molecules of water as they contain atoms of nitrogen (Schützenberger). These characteristics are those of nitriles. M. Berthelot has established experimentally that every time nitriles are combined with water to produce amido-acids, they give off a somewhat large quantity of heat, between one eighth and one-tenth of the amount which would be produced by the total combustion of these bodies in a calorimeter. These hydrations, i.e. the first stage of the destruction of the constituent albuminoids in our tissues, are consequently a somewhat important source of heat for the system. It will be seen directly that the energy thus produced is not due, in any way, to oxidation, and that this initial stage of cellular activity is entirely anaerobic. I have been the first to insist strongly on this very important point of the analysis of the phenomena of animal cellular life.

The transformation of carbo-hydrates into sugars and glycogen, into glucose by hydrolysis, liberates part of the latent energy of these principles. 1 grm. of starch by being changed into glucose and maltose, liberates 0·0026 Calories. The interversion with hydrolysis of cane sugar by yeast water produces 0·0112 Calories per gramme of modified sugar.[2]

The molecular decompositions in their turn became sources of heat. When sweetened must ferments, it becomes heated owing to the transformation of its glucose into carbonic acid and

[1] Bemerkungen über die Kraft (*Ann. de Leibig*, 1842).
[2] Brown and Pickering, Chem. Soc., t. LXXI, p. 783, and t. LXXII, p. 795.

alcohol; this reaction produces 0·167 Calories per grm. of fermented glucose. Similar modifications consisting of simply molecular decompositions occur at every moment in the various parts of the system. We know also to-day that our organs contain an alcoholic ferment. The transformation of sugars into carbonic acid and fats is another example of these decompositions, which are able to set free a part of the latent molecular energy of the principles which form our constitution.

A few simple isomeric modifications can, in their turn, produce heat; when cyanic acid, CNHO, which is so closely connected to urea and albuminoids, is changed *in vitro* into cyanuric acid, by trebling its molecule, it sets free 0·336 Calories per grm. of acid thus modified. The changes of glucose into lactic acid and of levulose into glucose are examples of isomeric transformations taking place in our organs and furnishing us with energy without any intervention of free oxygen.

But, as Lavoisier observed, the phenomena of oxidation are the most important sources of force and vital heat. These phenomena produce from 85 to 86 per cent. of total disposable energy. We have given in Chapter VI (p. 56) the table of theoretical degrees of heat which each alimentary principle exhibits in the calorimeter. On p. 59 will be found the total amount of heat actually observed in the case of a man shut up in the calorimetric respiratory chamber. It would be necessary to deduct about 14 per cent. of the total quantity of Calories really produced, in order to ascertain the true amount of heat due simply to the oxidations of these principles such as take place in our tissues.

It is by the agency of ferments that the receiving centres of sensations augment or reduce the activity of the organs which are continually furnished by alimentation with principles charged with latent energy. Slowly or quickly, according to the nature and order of succession of hydrolyzing, decomposing or oxidizing agents at work, the animal disposes at various points of variable quantities of energy which, in each organ, appears in the form of work, heat, chemical activity, etc., thus producing elementary functional activities, the disposition and order of which, directed by the nervous system, constitute the state of life.

PART II

Aliments

XI

RICHNESS OF ORDINARY ALIMENTS IN FUNDAMENTAL NUTRITIVE PRINCIPLES—CLASSIFICATION OF ALIMENTS

TAKING our stand on the statistics of the facts of alimentation observed on a large scale, and comparing them with the daily losses of the economy in nitrogenous and ternary principles, as well as with its wants in heat and its expenditure of mechanical work, we have arrived by very different methods, the results of which agree however, at a determination of the normal alimentary ration of an adult man. We have expressed it in weight of each of the three kinds of fundamental nutritive principles, albuminoids, fats and carbo-hydrates, which compose the ration for twenty-four hours, in the two principal states of repose or mechanical work. We shall see further on how age, sex, race, individual weight, exercises of the mind, climate, idiosyncrasies, and above all the different pathological states ought, in each case, to modify the different diets in quantity and proportion. But in order to calculate and realize them, starting from the usual alimentary principles, it is absolutely necessary to establish first the composition of the aliments which can operate in this way. By studying them and the preparations derived from them, we are able to state precisely our views and enlarge upon our means of action from the standpoint of rational alimentation, both for the healthy and the sick. Part II of this Work will treat of the origin, character, composition, variations, applications and derivatives of each of our usual aliments.

It would be practicable, for future reference and the calculation of the alimentary régimes, to give here, at once and from its very beginnings, in some synoptic pages easy to consult, the average composition, in fundamental nutritive materials and mineral substances, of our principal aliments. This is the object of the following tables. They allow us to calculate the amount of nutritive principles—albuminoids, fats, sugars or starches and minerals in a given alimentary diet, when we know the quantities of meat, bread, fats, vegetables, fruits, wine, etc., which compose it.

COMPOSITION OF ALIMENTS OF ANIMAL ORIGIN

COMPOSITION OF THE USUAL PRINCIPAL ALIMENTS WITH REGARD TO THEIR FUNDAMENTAL NUTRITIVE PRINCIPLES.[1]

(All those numbers are relative to 100 fresh parts in weight.)

Aliments.	Albuminoids.	Fats.	Other non-nitrogenous materials.	Salts.	Water.	Observations.
A. Meat of Mammals.						
Beef—average meat	20·96	5·41	0·46	1·14	72·03	According to J. Koenig, 42 analyses (average)
,, ,, of lean meat	20·71	1·74	—	1·18	76·37	J. Koenig
,, ,, fat ,,	16·75	29·28	—	0·92	53·05	,,
,, sirloin	19·17	5·86	—	1·38	73·48	0·17 extract matter
,, steak	20·4	1·97	0·4	1·9	74·7	0·97 ,, ,,
,, fillet (fresh)	17·94	15·55	—	0·78	65·11	0·62 ,, ,,
,, boiled ,,	35·1	2·1	—	0·9	56·9	Balland
,, roast ,,	22·9	5·19	0·5	1·0	70·00	,,
Cow (av.) fat meat	19·86	7·70	0·41	1·07	70·96	Koenig
,, ,, lean meat	20·54	1·78	0·01	1·32	76·35	,,
Veal (av.) fat meat	18·88	7·41	0·07	1·33	72·31	,,
,, ,, lean meat	19·86	0·82	—	0·50	78·84	,,
Mutton (av.) very fat meat	16·62	28·61	0·54	0·93	53·31	Koenig, Moser, Atwater
Average mutton	17·11	5·77	—	1·33	75·99	Mène, Petersen
,, ,,	17·52	5·23	0·4	1·25	74·9	0·49 extract mat. A. Gautier
Pork (av.) fat meat	14·54	37·34	—	0·72	47·40	Koenig & Hammerbacker
,, ,, lean meat	20·25	6·81	—	1·10	72·57	Mène, Petersen.
,, (ham)	15·98	34·62	—	0·69	48·71	,, ,,
,, salted and smoked	25·07	8·18	—	7·1	59·92	,,
Ham—smoked	25·0	36·5	—	10·0	27·0	,,
Beef—salted	21·8	11·5	—	11·7	55·0	Mène, Petersen
,, smoked and salted	27·10	15·35	—	10·59	47·7	J. Koenig
Horse (av. flesh)	21·71	2·55	0·46	1·01	74·27	According to J. Koenig
Hare (leg)	23·14	1·97	—	1·19	74·6	,, ,,
Venison	19·77	1·92	1·42	1·13	75·76	Von Bibra
Rabbit	21·47	9·76	0·75	1·17	66·8	,,
B. Meat of Birds.						
Meat of fat fowl	18·49	9·34	1·10	0·91	70·06	According to J. Koenig
,, lean fowl	19·72	1·42	1·27	1·37	76·22	,, ,,
Turkey (fairly fat)	24·70	8·50	—	1·20	65·60	Atwater
Goose	15·91	45·59	—	0·49	38·02	J. Koenig
Partridge	25·26	1·43	—	1·39	71·96	,,
Pigeon	22·14	1·00	0·76	1·00	75·10	Von Bibra
Duck—domestic	—	—	—	—	—	,,
,, wild	23·80	3·69	1·69	0·93	69·89	C. Krausch
Thrush	22·19	1·77	1·39	1·52	73·13	J. Koenig
C. Flesh of Fish and its Derivatives.						
Salmon (average)	21·60	12·72	—	1·39	64·29	Atwater and Woods
Fresh water eel	12·83	28·37	0·53	0·85	57·42	A. Almen
Fresh herring	14·55	9·03	—	1·78	74·67	Atwater and Woods
Mackerel (average)	19·36	8·08	—	1·36	71·20	A. Almen
Shad	18·76	9·43	—	1·35	70·44	Atwater and Woods
Haddock	16·93	0·26	—	1·31	81·50	W. O. Atwater

[1] A great number of the data of these tables, particularly those which are shown as being *averages*, are taken from the important work of J. Koenig, *Chemische Zusammensetzung der menschlichen Nahrungs und Genussmittel*, Berlin, 1889.—Several of the others are borrowed from various authors, especially from the works of M. Balland, principal chemist to the army; who has published them successively for 15 years in the *Comptes rendus de l'Acad. des sciences* and the *Journal d'hygiène et de médecine légale*, Baillière, publisher.

Aliments.	Albuminoids.	Fats.	Other non-nitrogenous materials.	Salts.	Water.	Observations.
Cod (*gadus morrhua*) (av.)	16·23	0·33	—	1·36	72·25	Atwater and Woods
Dab	18·71	1·93	—	1·01	78·35	,, ,,
Sturgeon	18·08	1·90	—	1·43	78·59	,, ,,
Sole	17·26	0·81	—	0·87	79·20	Balland
Pike	18·35	0·66	—	1·08	79·50	,,
Carp	15·71	4·77	—	0·54	78·90	,,
Trout	17·52	0·74	—	0·80	80·50	,,
Skate	22·08	0·45	—	0·17	76·40	,,
Dried and salted cod .	81·54	0·74	—	1·56	16·16	Av. of numerous analyses
Salted and smoked cod	27·07	0·36	—	22·10	50·54	Average
,, herring . . .	18·90	16·89	1·57	16·41	46·23	,,
,, and smoked herring	36·76	15·74	—	13·12	34·38	Atwater and Woods
Caviare (average) . .	30·79	15·66	1·67	8·09	43·89	—
D. Accessory parts of Animals: Offal, Blood, Brains, etc. Derivatives of meat.						
Blood of animals (on an average)	6·42	0·18	—	0·83	80·82	According to J. Koenig
Blood of beef . . .	7·09	0·22	—	0·87	79·61	Poggiale
,, mutton . .	8·82	0·18	0·20	0·98	79·80	,,
,, pork . . .	7·68	0·19	—	0·79	76·89	H. Nasse.
,, chicken . .	5·31	0·20	—	0·87	79·34	,,
Bacon—not salted . .	0·41	98·53	—	traces	1·26	J. Koenig
,, salted . . .	9·12	75·75	—	,,	9·15	Mène
Brains	—	—	—	,,	76·0	,,
Calf's liver	17·66	2·39	—	1·68	72·80	Von Bibra
Kidneys—veal . . .	22·13	2·77	—	1·25	72·85	,,
,, mutton . .	16·56	3·33	0·21	1·30	78·61	,,
Tripe—pork . . .	23·00	11·32	—	0·84	63·84	J. Koenig
Tongue—beef . . .	17·10	18·10	—	1·0	63·80	Atwater
Lights	12·37	2·46	0·21	3·93	81·03	J. Koenig
Liebig's Extract . .	30·86	—	3·20	22·39	15·26	A. Gautier
Beef tea	0·75	—	0·14	0·41	91·0	,, (0·38 soluble salts)
Lard (melted) . . .	0·26	99·04	—	traces	0·70	J. Koenig
E. Egg and its parts.						
Fowl's egg—entire . .	12·55	12·11	0·53	1·12	73·67	Av. according to J. Koenig
,, ,, the white .	12·87	0·25	0·77	0·61	85·50	,, ,, ,,
,, ,, the yolk .	16·12	31·39	0·48	1·01	51·03	,, ,, ,,
F. Milk and its Derivatives.						
Human milk (av.) . .	2·29	3·78	6·21	0·31	82·41	Casein 1·03, albumin 1·26
Cow's milk (av.) . .	3·66	3·62	4·48	0·68	87·22	,, 3·18, ,, 0·48
Cow, morning milk (av.)	3·24	3·06	4·88	0·74	88·08	—
,, evening ,, ,,	3·19	3·62	4·99	0·71	87·49	—
Ewe's milk	6·52	6·86	4·91	0·89	80·82	Casein 4·97, albumin 1·55
Mare's milk	1·89	1·09	6·65	0·31	90·06	—
Ass's milk	2·22	1·64	5·99	0·51	89·64	Casein 0·67, albumin 1·55
Skim milk (av.) . . .	4·03	1·09	4·04	0·72	90·12	Average
Preserved milk (without sugar)	11·92	12·42	14·49	2·18	58·99	,,
Preserved milk (with sugar)	11·79	10·35	50·06	2·19	25·61	Sugar of milk 13·84, ordinary sugar 36·22
Cream of milk . . .	3·76	22·66	4·23	0·53	68·82	Average
Butter	0·80 to 3·6	83·10	—	0·07 to 3·6	6 to 20	Swedish butter

COMPOSITION OF ALIMENTS OF VEGETABLE ORIGIN

Aliments.	Albuminoids.	Fats.	Other non-nitrogenous materials.	Salts.	Water	Observations.
Normandy butter (av.)	0·80	86·4	0·18	—	12·95	E. Declaux (0·80 casein) comprising the ash
Cheese, Gervais . . .	14·32	43·22	—	1·42	41·04	Average
„ Brie and Camembert	18·97	25·87	0·83	4·54	49·79	„ Payen, Duclaux
„ Cantal . . .	24·59	34·70	—	4·45	36·26	Duclaux
„ Cheshire . .	27·68	27·46	5·89	5·01	33·96	Payen, Wölcker
„ Gruyère or Emmenthaler	29·49	29·75	1·46	4·92	34·38	Average
„ Gorgonzola (av.)	25·91	32·14	0·23	4·00	37·32	Moser, Duclaux
„ Dutch (av.) .	28·21	27·83	2·50	4·86	36·60	2·43 salt added
„ Roquefort . .	25·25	30·61	1·90	5·39	36·85	3·10 of NaCl added on 5·39
„ Parmesan . .	41·19	19·52	1·18	6·31	31·80	Average
Whey	1·86	0·32	4·79	0·65	93·38	Average
Koumiss (of mare's milk)	2·24	1·46	1·91 alcohol, 1·77 sugar, milk	0·42	90·44	Av. with 0·91 lactic acid
„ do (of cow's milk)	2·66	1·83	1·14 alcohol, 4·09 sugar	0·68	89·10	„ „ 0·55 „ „
Kephir	3·45	1·44	0·75 alcohol, 2·41 sugar	0·43	91·21	„ „ 1·02 „ „
G. Molluscs. Crustacea. Reptiles.						
Oysters	8·7	1·43	—	2·04	80·5	Balland
Mussels	11·2	1·21	—	1·3	82·2	„
Snails	16·1	1·08	—	1·55	79·3	„
Turtle	16·2	1·16	—	2·91	77·6	—
Lobster	18·13	1·07	—	2·47	77·7	O. Atwater
Frogs	16·4	0·1	—	1·5	80·4	—
H. Cereals and their Flours; Bread.						
American corn (whole) .	11·60	2·07	69·47	1·79	13·37	Av. In addition 1·70 cellulose
French and foreign wheats (av.)	12·64	1·41	68·92	1·66	13·37	In addition 2·0 cellulose
Rye (whole) . . .	12·90	1·98	68·11	1·93	13·37	Av. and add 1·71 cellulose
Oats (whole) . . .	10·66	4·99	58·37	3·29	12·11	Av. of France. With 10·58 cellulose
Wheat flour	10·21	0·94	74·71	0·48	13·37	Av. with 0·29 cellulose
Rye flour	11·57	2·08	68·61	1·14	13·71	„ „ 1·59 „
Barley flour . . .	11·38	1·53	71·22	0·59	14·83	„ „ 0·45 „
Oat flour	9·65	3·80	69·55	1·33	14·21	„ „ 1·46 „
Buckwheat flour . .	8·87	1·56	74·25	1·14	13·51	„ „ 0·67 „
Maize flour	7–12	7–4	60–68	1·1	17·4	
Rice flour	5–6·4	0·8–4	78–83	0·68	14·4	
Fresh wheat bread . .	7·0–9·3	0·85	46–55	0·6–1	33–40	Crust, 22–25; crumb, 77 to 75 per cent.
„ „ average .	7·06	0·46	52·56	1·09	35·59	Fine German bread. Besides, sugar 4·02 and cellulose 0·32

Aliments.	Albuminoids.	Fats.	Other non-nitrogenous materials.	Salts.	Water.	Observations.
Rye bread	6·11	0·43	46·94	1·46	42·27	Besides, 2·31 sugar; cellulose 0·49
Rye bread made with whole grain [1]	7·59	1·51	41·87	1·42	43·42	Besides, 3·25 sugar, 0·94 cellulose
I. Seeds of Leguminosæ.						
Haricot, dry (whole) .	13·8 –25	1·95	52·9 –60 [2]	2·3–4	10–20	Balland
„ „ (average) .	23·6	1·96	55·6	3·66	11·24	According to many (with 3·88 cellulose)
Broad beans, dry (av.).	22·26	1·5	57·5	2·5	13·0	According to many (with 3·88 cellulose)
Lentils, dry (average) .	20·3–26·8	2·4–1·5	56–62 [3]	2–2·66	11–13	Balland.
Peas (average) . . .	18·9–24·5	1·2–1·4	52·2–61·1 [4]	2·2–3·5	10·6–14	„
„ „ . . .	23·15	1·89	52·7	2·6	13·92	With 5·6% cellulose
Soja trispida, yellow .	33·41	17·68	29·31	5·10	9·89	Av. with 4·67% cellulose
K. Tubercles.						
Potatoes (average) [5] .	1·3	0·15	20·0	1·0	76·0	Balland.
„ Dutch . . .	1·83	—	—	—	77·9	„
„ called red sausage	1·46	—	—	—	76·9	„
„ called royal blue	1·56	—	17·3	—	72·8	„
Sweet potatoes . . .	1·50	0·3	16·5	2·6	67·5	Payen.
Manioc	1·17	0·4	28·3	0·65	67·6	„
L. Herbaceous Vegetables; edible Stalks and Roots; Mushrooms.						
Beetroot—edible . .	1·34	0·14	8·90	1·14	87·50	Average; J. Koenig
Sugar Beetroot . . .	1·27	0·12	14·40	0·82	82·25	„ „ with 1·14 cellulose
Pumpkin—edible . .	1·10	0·13	6·50	0·73	90·32	Average
Asparagus	1·79	0·25	2·63	0·54	93·75	„ with 1·04 cellulose
Cauliflower	2·48	0·34	4·55	0·83	90·89	„ „ 0·91 „
Headed cabbage . .	1·89	0·20	4·87	1·23	89·97	„
Turnips	1·54	0·21	8·32	0·91	87·8	„ J. Koenig
Boletus (*Boletus adulis*)	2·92	0·51	4·72	0·63	90·06	F. Ströhmer
Mushroom—field (fresh)	3·74	0·15	3·51	0·48	91·28	Average
„ cultivated	4·67	4–0·20	3·13	0·46	91·0	—
„ (cèpes) .	4·89	0·65	2·98	0·83	90·6	—
Truffles—black . . .	8·60	0·62	8·10	2·31	72·80	„ J. Koenig
Carrots	1·23	0·30	9·17	1·02	86·79	„ with 1·49 cellulose
Spinach	3·49	0·58	4·44	2·09	88·47	„
Salad (endive) . . .	1·46	0·13	1·58	0·78	94·13	„ with 0·62 cellulose
M. Oily Fruits.						
Almonds	24·2	53·7	9–7	2·9	5·4	66 % waste
Nuts (average) . . .	15·77	57·43	13·03	2·0	7·18	J. Koenig
Hazel „ . . .	17·41	62·60	7·22	2·49	7·11	„
Chestnuts	4–8	0·87	35·6	1·52	53·7	Moleschott
Cocoa (nibs) . . .	8·88	67·0	12·44	1·81	5·81	4% of cellulose.

[1] German Pumpernickel.
[2] Not including 2·5–4·6% of cellulose.
[3] Not including 3–3·5 % of cellulose.
[4] Not including 3–3·5% of cellulose.
[5] Three kgs. of fresh potatoes or 1,200 grms. of fried potatoes, contain about as much starchy and nitrogenous matter as 1 kg. of white bread.

COMPOSITION OF ALIMENTS OF VEGETABLE ORIGIN

Aliments.	Parts soluble in Water.					Insoluble parts.		Observations.
	Water.	Albuminoids.	Free Acids.	Sugars.	Pectic Bodies.	Stones and Skins.	Ashes and Pectoses.	
N. Sweet or Acid Fruits.								
Apples—edible (av.)	84·79	0·36	0·82	7·22	5·42	1·51	0·49	About 0·2 insoluble ash
„ (maximum)	89·0	0·59	1·88	10·68	—	3·79	1·03	„ 0·5 „ „
Plums (Mirabelles) .	79·4	0·38	0·53	3·97	10·07	4·99	—	R. Fresenius
Greengages . . .	80·3	0·41	0·91	3·16	11·46	3·39	—	„
Peaches (average) .	80·0	0·65	0·92	4·48	7·17	6·06	—	Fresenius, Murgold
Apricots „ .	81·2	0·49	1·16	4·69	6·35	5·27	—	„ „
Cherries „ .	79·8	0·67	0·91	10·24	1·76	6·07	—	„ „
Pears „ .	83·8	0·36	0·20	8·26	3·54	4·30	—	J. Koenig
Strawberries „ .	87·7	0·54	0·93	6·28	0·48	2·85	0·81	With 0·53 fat
Grapes—French .	77–81	0·6	—	14–22	—	—	0·53	—
„ (av. from German vineyard)	78·17	0·59	0·79	14·36	1·96	3·60	0·3	R. Fresenius, Neubauer
Prunes	29·3	2·25	2·75	44·90	4·48	—	1·37	J. Koenig
Pears (preserved and dried)	29·4	2·07	0·84	29·48	4·47	6·87	1·67	10·33 starch added
Apples (preserved and dried)	27·9	1·28	3·60	43·65	4·84	4·99	1·57	With 5·56 starch
Raisins	32·0	2·42	2·52	54·56	—	1·72	1·21	—
Figs—dry . . .	31·2	4·01	—	49·79	—	—	2·86	—
Dates	—	0·2	—	61·0	—	—	—	With 0·51 fat

Aliments.	Water.	Alcohol in weight.	Total Extract.	Albuminoid matters.	Sugars.	Gums.	Free Acids.	Ash.	Observations.
O. Fermented Liquors; Alcohol (for 100 parts in weight).									
Red wine—Bordeaux	—	7·80	2·56	0·27	0·30	—	0·57	0·248	Av. 0·73 glycerin added
White wine—Bordeaux	—	8·24	3·03	—	—	—	—	0·25	Av. 0·97 glycerin added
Red wine—Burgundy	—	7·8	—	—	—	—	—	0·18	Av. 0·70 glycerin added
Red wine from the South (France)	—	8·8	—	—	—	—	—	0·30	Av. 0·6–1·0 glycerin added
Tokay wine . .	—	9·03	23·6	—	19·73	—	0·51	0·71	Average
Rhenish wine—white	—	8·0	2·60	—	0·20	—	0·81	0·23	Av. with 0·85 glycerin
Rhenish wine—red	—	8·0	3·04	0·32	0·39	0·15	0·52	0·25	C. Neubauer
Hungarian wine—white	—	8·0	2·35	0·17	0·07	—	0·69	0·20	Av. with 0·77 glycerin
Cider (average) .	—	2·92	6·35	—	1·72	—	0·37	0·26	J. Koenig
Light beer „ .	90·53	3·24	6·23	—	0·20	3·52	0·14	0·23	„
Beer (average for home consumption)	90·10	3·93	5·79	0·71	0·88	3·73	0·15	0·23	Av. 0·165 glycerin added
German beer of exportation	89·01	4·40	6·38	0·74	1·20	2·47	0·16	0·25	J. Koenig. Average
Ale	89·42	4·73	5·65	0·61	1·07	1·81	0·28	0·31	„ „
Brandy . . .	—	37–48	0·16–0·5	—	—	—	0·012–0·08	—	— —
Kirsch . . .	—	38·6–42·4	—	—	—	—	0·4–1·8	—	With 3–15 mgrms. of CNH per litre

Aliments.	Albuminoids.	Fats.	Other non-nitrogenous materials.	Salts.	Water.	Observations.
P. Other various Aliments.						
Chocolate in tablets (av.)	6·18	21·02	sugar 54·40 starch 4·40	1·89	1·89	With 0·67 theo-bromine
Brown cane sugar . .	0·35	—	95·11	0·76	2·16	With 1·78 of inverted sugar and 0·30 gums and acid.
Honey (average) . .	0·76	—	74·64	0·25	30·6	3·7 non-nitrogenous ext. mat.
Sugar of starch . . .	—	—	64·33	0·66	16·99	Of which 18·02 substances are organic materials not transformed into sugar.

Decoction in water of	Dry Extract.	Nitrogenous Substances.	Essential Oil.	Non-nitrogenous Substances.	Ash.
100 grms. of roasted coffee .	25·50	3·12	5·18	13·14	4·06
100 grms. of ordinary dry tea .	33·64	12·38	—	17·61	3·65

These tables enable us to determine easily the richness of any portion in fundamental nutritive principles and of afterwards calculating it in Calories.[1] They put before us the average composition of all our usual foods, neglecting for the moment their variations and accessory parts which will be treated successively in each case.

These numerical data thus brought together give rise to the following remarks :

Our foods provide us with the fundamental alimentary principles in very different proportions.

The albuminoid bodies vary from 23 to 13 per cent. in the flesh of mammals, birds, crustacea and some fish, while in salted or smoked meat and fish, they represent about a fifth of the weight of boned butcher's meat. The albuminoid matters in seed vegetables rise as high and even higher than 25 per cent. In boiled beef or mutton they reach 35 per cent. In cheese they vary from 15 to 44 per cent.

We find from 13 to 8 per cent. of proteid substances in offal, brains, eggs, the flesh of some very fat fish, oysters, the meal of cereals, bread.

[1] On page 59 will be found the usual coefficients by which the weights of each of these principles ought to be multiplied, according to their origin, in order to obtain the real quantities of heat furnished by them during combustion in the bodies of animals.

The proteid bodies only rise from 7 to 2 per cent. in milk, rice, mushrooms, dry fruits, starches and fats.

They fall to 3 and even 1·5 per cent. in some milks, such as human and ass's milk, in koumiss and kephir, in potatoes, cabbage, spinach, salad and mushrooms.

They remain below 1 per cent. in most of the acid or aqueous fruits, fermented drinks, honey and chocolate.

The *fatty bodies* vary from 99 to 85 per cent. in suet, lard, ordinary fats, butter, etc.

From 62 to 45 per cent. in almonds, nuts, hazel-nuts, cocoa and also in *foie gras.*

From 40 to 15 per cent. in fat meats, dry cheeses, the yolk of eggs, many very fat fish and chocolate.

From 15 to 2 per cent. in fish in general.

From 8 to 2 per cent. in the flesh of birds, offal, etc.

From 4 to 1·8 per cent. in the lean meats of mammifers, birds, fish, game, liver, milk and in the majority of cereal flours.

From 2 to 1 per cent. and under, in some fish with very lean flesh, blood, oysters, bread, dry vegetables, etc.

Fats fall below 1 per cent. in potatoes, sweet potatoes, manioc and green vegetables.

They are wanting in the majority of the fruits of rosaceae and in fermented liquors.

The carbo-hydrates (sugar, starches and analogous bodies) vary from 78 to 58 per cent. in grains and cereal flours.

From 57 to 46 per cent. in bread and the majority of grain vegetables.

From 28 to 16 per cent. in potatoes, sweet potatoes and manioc.

From 15 to 7 per cent. in almonds, apples, cherries, grapes, the majority of root vegetables and in truffles.

From 9 to 5 per cent. in many fruits, in ordinary mushrooms, carrot, turnip and also in milk.

From 4 to 1 per cent. in some mushrooms, herbaceous vegetables, salad, offal; in extracts of meat and in nearly all cheeses.

From 1·2 to 0·5 per cent. in eggs, beer, koumiss, kephir and butter.

From 0·5 to 0·1 per cent. in meat, beef-tea and dry wines.

The *mineral salts* vary in animal matters from 0·02 (milk) to 5·7 per cent. (cheese).

In the vegetable matters they vary from 0·5 per cent. (aqueous fruits) to 5 per cent. (cocoa).

These remarks are interesting from the standpoint of application. They allow us to choose in the very varied aliments furnished us by the two régimes, those which can introduce in the greatest abundance into our system, such or such necessary principles—nitrogenous bodies : mineral principles for example. They indicate to us how we may cause to disappear, as much as

possible, from alimentation, certain substances which have become harmful—fats and starches in the case of obese people; sugars and other carbo-hydrates in the case of diabetics, etc.

For the moment, we will draw from these data this immediate inference, viz. that it is not in the chemical constitution of aliments that we must seek for the principle of their classification. Without doubt, and in a general manner, we can say that animal aliments bring us above all proteid and plastic substances, and vegetable aliments, the carbo-hydrates or calorific or respiratory principles as well as mineral salts; but, on the one hand, we see the leguminous fruits, peas, beans, lentils, haricots and some of the rosaceae, such as almonds, are richer in albuminoids than meat itself; and on the other hand, that this latter, by means of the fat which accompanies it, can constitute a heat producing aliment as powerful as the vegetable aliments which are the richest in starchy or fatty substances.

It is not owing then to the constitution or the richness in such and such immediate fundamental principles that we are able to class aliments. Above all, we will take notice of their origin, conforming in this to the usual practice and also to different theoretical considerations. We have, in fact, shown that the different proteid or plastic principles do not possess the same nutritive value or the same assimilability, although their composition varies very little. According to their origin, be it animal or vegetable, they are more or less beneficial to us; a certain quantity of albuminoids borrowed from the meat of mammifers, nourishes better than the same weight of proteid compositions furnished, for example, by the leguminosae.

On the other hand, as we shall see, each aliment tends to modify the living tissues and the functioning of the individual in a manner which is peculiar to itself: those of animal origin by acidifying the humours, moderating the oxidations, introducing into the plasmas some nitrogenous derivatives—stimulating and sometimes harmful; those of vegetable origin, on the contrary, by alkalization of the plasmas, and by bringing to them in abundance and in assimilable form, iron, phosphorus, alkalies, lime, magnesia, etc., of which they have need. This remark will amply suffice to maintain the division of aliments into those of animal and vegetable origin, whatever may be their relative richness in proteid or ternary principles.

By virtue of these considerations, we will first divide the alimentary substances into *organic* materials (meat, milk, grains, vegetables, etc.) and into *inorganic* materials (water, salt and different salts).

In the organic aliments we will study:—

1st. *The organic aliments of animal origin* comprising: the flesh of mammifers, birds, fish, crustacea, shellfish and the deriva-

tives of meat—eggs and milts—milks and the alimentary substances which come from them—fatty bodies of different origins.

2nd. *The organic vegetable aliments* comprising: bread and the different flours; vegetables in grain (peas, haricots, beans, etc.); potatoes, manioc and other edible roots; herbaceous vegetables; fruits proper, sweet, acid and oily.

3rd. *Aromatic and sweetened aliments and condiments* comprising coffee, tea, cocoa, spices and different condiments, including sugar.

4th. *Alcoholic beverages* such as wine and other fermented liquors: cider, beer, alcohol, etc.

5th. *Mineral aliments*, that is to say drinkable water, salt and the other mineral substances which serve to nourish us.

A propos of each of these aliments we shall have to show their origin, composition, characters, derivatives, their rôle in alimentation, and if need be, the mechanisms of their activity.

XII

MEAT—ITS CONSUMPTION—THE FLESH OF EDIBLE MAMMIFERS

MAN has always lived on fruits and meat. From his earliest existence he has hunted and devoured animals, as the bones found in the caverns of the quaternary period testify. Even at the present time in the most wild and miserable countries, man tries to capture animals, and in default of them, man himself, in order to obtain food.

At this time, the most active and enterprising people are those who eat most meat. The rate of consumption of this food is raised everywhere in Europe with modern comfort and activity. Before the Revolution, it was scarcely eaten at all by the French peasant. Taine, in *Origines de la France contemporaine*, says: "According to the reports of the Commissaries, the foundation of his nourishment is oats; in the district of Troyes, buckwheat; in la Marche and Limousin, buckwheat with chestnuts and beetroots; in Auvergne, buckwheat, chestnuts, curdled milk and a little salted goat; in Beauce, a mixture of barley and rye; in Berry, of barley and oats. No wheat bread, no butcher's meat; at the most, he kills one pig a year."

The progress of civilization has greatly changed this state of things in all European countries, at least those of the Latin or Anglo-Saxon races. In 1852, in France, the average consumption of meat was already 20 kgs. per head per year. It reaches to-day 38 kgs. The English citizen eats in the year 59 kgs. of meat or its derivatives.

Here are the statistics which I have drawn up of the consumption, per head and per year, of the whole of the foods of animal origin in the various large towns of France[1]:

[1] According to the official reports of the Municipal Services and the registers of the octroi of the different towns quoted in this table.

Towns.	Years.	Butcher's Meat.	Cooked Meats.	Poultry and Game	Fish.	Total of aliments of Animal Origin.
		Kgrm.	Kgrm.	Kgrm.	Kgrm.	Kgrm.
Paris	1887	67·1	10·3	11·2	13·7	102·3
	1891	63·6	10·2	10·6	11·2	95·6
	1896	61	9·8	11·5	11·1	93·4
	1899	72·9	12·9	12·5	15·80	113·1
Lyons	1887	58	1	5·4	2·4	66·8
	1891	55	0·6	4·9	2·5	61·0
	1896	50	0·5	5·4	2·0	57·9
Bordeaux	1887	64	2·5	13	8·3	88·4
	1891	57·6	3·4	10·2	9·3	79·5
	1896	56·4	4·8	12	9·0	82·2
Marseilles	1887	54·7	1·5	3·4	6·3	61·9
	1891	49·4	1·3	2·7	6·0	59·4
	1896	45·2	1·4	2·9	5·5	55·0
Rouen	1896	47·3	17·1	5·8	15·5	85·4
Havre	1895	36·1	9·6	2·5	11·0	59·2
	1896	35·2	10·2	2·7	11·0	59·5

Thus Paris consumes annually, per head, about 94 kgs. of meat and other foods of animal origin; Rouen 85·4; Bordeaux 82·2; Lyons 57·9; Havre 59·5 and Marseilles 55 kgs. The average of these six large towns is 72 kgs., much higher than the average consumption of the whole of France, which is at this time only 38 to 39 kgs., being 106 grms. of fresh meat per day and per head instead of 269 grms. which the Parisian receives and which, as we have seen, corresponds to a normal rate. In a word, too little meat is eaten in our country places, and if more is consumed in the towns, where there is the most comfort, yet sensibly less of it is eaten than in England, where the consumption of animal matter is nevertheless not excessive, rising only to 59 kgs. on an average in opposition to 94 kgs. per head and per year in the city of Paris, which is far from being extreme as I have shown.

From these statistics, we conclude that it is desirable that the consumption of meat should increase in general without, however, reaching the high rate which it attains in certain well-to-do families of Paris or London.

We shall observe that the preceding tables establish that the consumption of meat has tended to diminish in France for some years: at Paris it was above 103 kgs. per year and per head in 1887; in 1896 it was 93 kgs. It was on an average 94 kgs. for the eleven years 1890–1900. At Lyons, it has fallen from 67 kgs. per head and per year to 58 kgs.; at Marseilles, from 66 to 55 kgs. It is grievous to note, at the same time, in proportion as the quantity of meat consumed diminishes, that of alcohol proportionally increases. In France it was 2·70 litres per head and per year in 1870; 3·70 litres in 1885; it has risen to 4·07 litres in 1895; and its consumption is

still greatly increasing. It exceeds 9 litres in Denmark, 8 litres in Northern Germany, 5 litres in Switzerland and Holland, 4 litres in Sweden, etc. That is a state of things doubly to be deplored which a false conception of immediate fiscal interest and our regrettable present political morals keep up, at least in France, to the great detriment of the nation's future.

We have seen that meat is pre-eminently the food of the worker, and he seems to want in France about 100 to 110 grms. of meat in twenty-four hours, if we rely on the conclusive observations of the régime adopted by the administrations and by the workmen collectively who produce the maximum of daily labour. Now, everywhere where the workman lacks meat, he drinks alcohol: this was remarked long ago by Liebig, and we shall have to revert to it on several occasions. For the moment, it suffices for us to have shown that, in our large towns, the consumption of alcohol increases in proportion as the consumption of meat diminishes.

Muscular tissue is the principal food borrowed by man from the animal kingdom. We will speak later of that of birds and fish. Meat called butcher's meat, which forms the principal subject of this chapter, comes especially from oxen, calves, and sheep. These animals furnish a little more than half of their living weight of it. As regards the remainder of saleable meat it contains for 100 parts, 10 to 23 parts of bone and aponeurosis, [1] from 4·5 to 13 parts of fat, and from 64 to 83 parts of muscular tissue proper including the interstitial fat of the muscular fibres, so that on an average, per kg. of butcher's meat, we can reckon:

Bone and aponeurosis	200
Adipose tissue	60
Flesh proper	740
	1,000

These practical references have their importance in the calculation of food and diets.

Whatever be its origin, flesh of good quality ought to be bright red, firm, elastic, grainy to the touch and close grained; of a fresh and sweet odour. When cut, there oozes out under pressure a very minute quantity of clear red juice, slightly acid to litmus. On cutting good meat, fine branchings are seen which arise in well nourished animals from the infiltration of the muscular tissue by fat. They give to these meats, generally excellent when they present this character, a marbled or spotted look of yellowish white upon bright red.

Meat possesses a density of 1·055.

[1] In butcher's meat sold retail, bones represent from 18 to 20 per cent. on an average.

Albuminoid elements form almost the whole total of the utilizable material of muscle separated from its adipose tissue.

Treated by water, muscular tissue leaves *an insoluble part a*, and gives *a soluble part b*.

a. The *insoluble part* is itself composed of three essential albuminoid principles, *myosin*, *myostroin* and *ossein*. The first, myosin, an albuminoid principle of the globulin class, forms 8 to 11 hundredths of the weight of fresh muscle. It proceeds from coagulation, after death, of a syrupy and homotropous substance, which forms during life the clear part of the contractile fibrillae of striated muscles. It is an insoluble substance in water; at the same time, like all the proteid bodies, nitrogenized and sulphurated (composition: C = 52·5; H = 7·0; N = 16·7; O = 22·3; S = 1·5). It dissolves, although slowly, in aqueous solutions of neutral salts alkaline to 5 or 10 per cent. (nitrates or chlorides), giving thus liquors coagulable towards 60 to 70° and precipitable by an excess of chloride of sodium or sulphate of magnesia. Myosin also dissolves in water containing 1 to $\frac{1}{2}$ thousandth of hydrochloric acid while transforming itself into *syntonin*.

It is easily digested, even *in vitro*, by the gastric juice in acid liquor.

Myostroin which accompanies myosin, albuminoid and like it insoluble, varies in the flesh of adult animals between 4 and 5 per cent. of the weight of fresh muscle. It is that which constitutes the obscure striae of the fibrillae of red muscles. It is essentially formed by one or several nucleo-proteids and differs from the myosin by its insolubility in a solution containing $\frac{1}{1000}$ th part of hydrochloric acid. We must remember here that the nucleo-proteids, which are met with especially in the nuclei of young cells, are the phosphorated albuminoid substances, which water, helped by acids or the pepsic digestion, divides into albuminoids and *nucleins*. These latter transform themselves in the small intestine, by a more advanced hydrolysis, into peptons and *nucleinic acids*, acids fit to separate in their turn, by fresh hydration, into orthophosphoric acid, thymin or other bases of the pyrimidic series, carbo-hydrates and puric bodies (guanin, adenin, cytosin, uric acid, etc.). These last derivatives are not formed, if the primitive phosphorated proteids proceed from the cytoplasmas (*cytoproteids* or *paranucleins*).

It is by myostroin that the muscle furnishes phosphorus to the system at the same time that it carries to it the radicals which, by simple hydrolytic divisions, appear in the form of uric acid and other puric compounds playing a large part in troubles of the heart, as soon as their elimination becomes imperfect.

Ossein forms in the muscle the sarcolemmae and inter-

fibrillar membranes which, by boiling in water, are tansformed into gelatin which, under the influence of cold water, coagulates into the form of *meat jelly*.

b. The *albuminoid part of muscular flesh soluble in water* contains two substances forming together scarcely 2 to 3 per cent. of the weight of fresh meat, viz. an albumin and some peptons.

The muscular albumin or *myoalbumin* which only represents about 1 per cent.of the total weight of the muscle,can be extracted by cold water. Heat causes it to coagulate. It is this which, during boiling, forms the *scum* on broth from meat, scum which is generally rejected. As to the peptons, a certain proportion of them are always found in the freshest meat, about a half to 2 per cent. Their quantity increases in proportion to the time the meat is kept; the latter digests itself, or, as is generally said, *becomes tender*, before it is invaded by putrid ferments. The process of the meat becoming tender is then a kind of auto-digestion. In the case of meat kept under certain conditions in a damp state protected from putrefactive changes, it has been observed that this auto-digestion may cause to pass into a soluble state up to 12 per cent. of muscular matter, partly transformed into a soluble but coagulable albumin and partly peptonized. I have observed that at the time of this transformation, there appears also a weak quantity of a substance analogous to casein.

When the muscular tissue, minced or grated, is again treated by cold water, there is left in an insoluble state myosin, myostroin, aponeuroses and fats, but the small quantities of myoalbumin and peptons which it contains, as also a small quantity of red colouring matter identical or very analogous to that of blood, and various substances soluble in water, are dissolved, as well as lecithins, leucomains, or muscular bases, inosit, glycogen, lactic acids, different mineral salts. All this soluble part, albuminoids excluded, scarcely represent 2 to 3 per cent. of the weight of the meat. The soluble mineral salts (about 0·5 to 0·7 per cent.) are composed of chloride of potassium with very little chloride of sodium, a trace of sulphates, but especially a great deal of bibasic phosphate of potash. There remains in the meat, drained by the cold water, myosin, myostroin, ossein, forming the aponeuroses, tendons and fats and about 0·5 per cent. of insoluble salts composed of phosphates of lime, magnesia and iron.

These principal constituent materials of the flesh of mammifers, deprived of bone and rolls of adipose tissue, are in the following relations, calculated for 100 parts:

Myosin	8–11	Average of albuminoids 18·5 per cent.	Extractive matters	2–3
Myostroin	4–5		Soluble salts	0·5–0·8
Ossein and peptons	2–3		Insoluble salts	0·3–0·5
Myoalbumin	1·5–2·5		Water	74·5–78

MUSCULAR FLESH

The table below gives the composition of the fresh muscular tissue of various edible animals, after the packs of adipose tissue, interposed between the muscular strata, have been removed as much as possible.

Composition of the Flesh of the usual Edible Mammifers.

	For 1,000 parts in weight of Fresh Muscle.					
	Mammifers in General.	Beef.	Beef (A. Gautier).	Veal.	Mutton. (A. Gautier).	Pork.
a. Water . . .	600–783	600–780	747	723	749·2	474–725
b. Organic matters—						
Myosin . . .	35–106	175	109·6	146	83·1	168
Myostroin or nucleoproteids	78–161		43		44·9	
Myoalbumin .	27–32	22	30·6	26	33·2	20–88
Elastin, keratin and indigestible substances	—	—	2·4	—	8·6	—
Gelatinous bodies and pre-existing peptons . .	—	13	22·4	16	13·3	8–50
Fats. . . .	35–160	12–124	19·7	74	52·3	68–373
Glycogen . .	4–5	—	3·8	—	4	—
Creatin . . .	2	—	9·7	4	4·9	—
Xanthic bodies	0·4–0·7	—				
Inosic acid . .	0·1	—				
Taurin . . .	0·7 (horse)	—				
Inosit . . .	0·03	—		0·7		
Lactic acid . .	0·4–0·7	—				
Unknown extractive matters	—	—				
c. Mineral matters—						
Soluble . . .	—	19–20	6·5	13·3	6·0	7·2–11·5
Insoluble . .	—		4·4		6·5	
containing—						
Phosphoric acid (P^2O^5)	3·4–5	—	—	—	—	—
Potash (K^2O) .	2·9–5	—	—	—	—	—
Soda (Na^2O) .	0·2–0·8	—	—	—	—	—
Lime . . .	0·7–0·16	—	—	—	—	—
Magnesia . .	0·2–0·45	—	—	—	—	—
Chlorine . .	0·1–0·7	—	—	—	—	—
Fe^2O^3 . . .	0·03–0·10	—	—	—	—	—
Total sulphur (measured in sulphate)	0·03–0·1	—	—	—	—	—

For 100 parts of the flesh of beef, veal or mutton, the minimum, maximum and average of bases and acids have been, according to the analysis of E. Wolff:

	Minimum.	Maximum.	Average.
K^2O	25	48·9	37·04
Na^2O . . .	0·0	25·6	10·14
CaO	0·9	7·5	2·42
MgO	1·4	4·8	3·23
Fe^2O^3 . . .	0·3	1·1	0·44
P^2O^5	36·1	48·1	41·20
SO^3	0·3	3·8	0·98
Cl	9·6	8·4	4·66
SiO^2	0·0	2·5	0·69

In the ash of muscle, phosphoric acid, which comes chiefly from the nucleins, is united to the extent of two-thirds to the potash; another part, not finding sufficient bases to saturate, renders this ash acid. The sulphuric acid that we find there comes especially from the sulphur of the albuminoids. It follows that the destruction of meat in the system tends to acidify the blood both by the mineral acids and the organic acids (uric, lactic, etc.), which originate from its decompositions.

Muscular tissue, as well as the rest of the fats, has not the same taste, the same composition, nor the same nutritive and venal value for the various parts of the animal. Practically it is

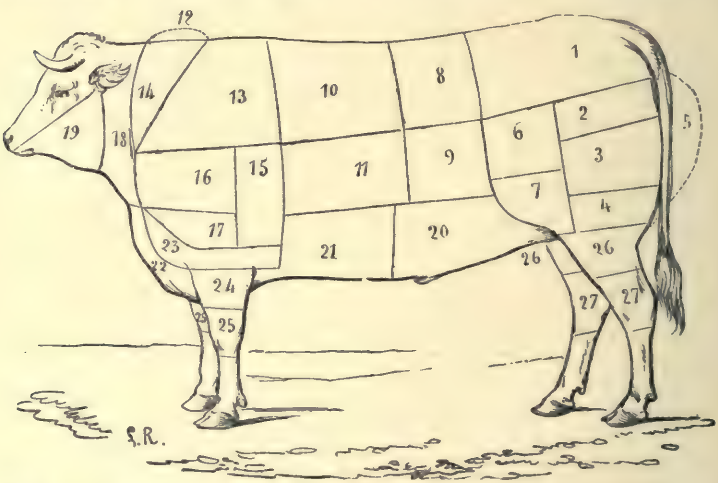


FIG. 3.—1. Rump. 2. Steak with little bone. 3. Round. 4. Back. 6. Fillet (interior part). 7. Round of beef. 8. Sirloin with fillet. 9. and 11. Top ribs. 10. Gristle ribs. 13. Back of shoulder bone. 14 and 19. Sticking. 16 and 17. Clod of beef. 18. Neck. 20. Flank. 21. Plate of beef. 23. Brisket. 24. Shin. 25. Lower Shin. 26. Leg of beef. 27. Lower Leg of beef.

necessary, from this point of view, to class and name each of them. We give here (Fig. 3 and legend) the indication and name of the principal parts of the animal, as distinguished by the retailer who cuts them up and places them on sale, each of them at very different prices.

Here are besides, examples of the composition of various parts of muscular tissue taken from the same animal:

CENTESIMAL COMPOSITION OF DIFFERENT PARTS OF AN OX (Ch. Mène).

	Shoulder.	Rump.	Sirloin.	Round of Beef.	Midrib.	Fillet.	Upper Cut.
Water	70·83	72·50	74·60	68·91	72·10	71·20	71·40
Soluble albuminoids [1]	3·09	3·65	2·50	4·05	4·73	2·01	2·71
Tendons & membranes [2]	15·21	10·49	13·53	13·53	10·10	11·46	8·18
Collagenous and waste matters	6·33	7·18	3·01	8·45	5·71	4·71	6·10
Fat matters . . .	3·08	5·16	5·42	4·16	6·41	9·86	9·60
Mineral salts . . .	1·45	1·01	0·92	0·90	0·95	0·75	2·01
P^2O^5 [3]	0·42	0·19	0·33	0·30	0·29	—	0·21
Total nitrogen for 100 parts	4·41	3·55	30·6	5·11	3·35	3·51	4·51

CENTESIMAL COMPOSITION OF THE DIFFERENT PARTS OF A CALF FOR 100 FRESH PARTS.

	Shoulder.	Fillet.	Neck.	Brisket.	Cutlet.
Water	76·57	72·50	75·21	69·66	76·26
Soluble albuminoids [4]	2·01	2·03	1·49	1·53	1·33
Tendons and membranes . . .	3·09	8·14	2·20	6·49	6·72
Collagenous and waste matters [5] .	13·00	13·11	13·83	13·12	12·51
Fatty materials	3·62	2·68	6·18	7·42	5·12
Mineral salts	1·71	1·54	1·08	1·78	1·67
of which P^2O^5 = ...	0·11	0·12	0·07	0·10	0·07
Average of P^2O^5 = 0·09 grms. p. 100					
Total nitrogen for 100 parts . .	2·92	3·12	2·30	2·30	2·[illegible]2

The average of a large number of percentage analyses of beef and veal, fat and lean, has given according to J. Koenig:

[1] Part of the muscular flesh soluble in cold water with the addition of a thousandth of HCl.

[2] Part resisting to water diluted with HCl, afterwards to boiling.

[3] The average in P^2O^3 is from 2g·9 for 1,000 parts of meat.

[4] Part of the muscular flesh soluble in cold water with the addition of a thousandth part of HCl.

[5] Parts resisting to water diluted with HCl, then to boiling.

	Beef.			Veal.	
	Very fat Meat.	Average Meat.	Lean Meat.	Fat Meat.	Lean Meat.
Water	53·01	72·03	76·37	72·31	78·84
Nitrogenous matters	16·75	20·96	20·71	18·88	19·86
Fatty matters	29·28	5·41	1·74	7·41	0·82
Non-nitrogenous extractive matters	—	0·46	—	0·07	—
Mineral salts	0·92	1·14	1·18	1·33	0·50

According to Mène, the composition of the most edible parts of sheep is as follows:

Composition of the Different Parts of the Flesh of Sheep (for 100 fresh parts.)

	Leg.	Shoulder.	Chop.	Neck.
Water	75·50	75·70	75·50	74·53
Soluble albuminoids [1]	3·82	4·14	3·54	3·25
Tendons and membranes [2]	10·28	9·75	10·50	11·54
Collagenous and waste matters	0·15	0·14	0·28	0·85
Fatty matters	8·76	9·03	8·55	8·52
Mineral salts	1·47	1·26	1·62	1·32
of which P^2O^5 =	0·065	0·078	0·180	0·090
Total nitrogen	1·68	1·99	1·69	1·57

The average composition of the flesh of sheep according to the numerous analyses of J. Koenig and Mütschler, Moser and Meisl, O. Atwater, Mène, Petersen, etc., is as follows:—

	Very fat Mutton.	Average Mutton.
Water	53·31	75·99
Nitrogenous matters (particularly albuminoids)	16·62	17·11
Fatty matters	28·61	5·77
Non-nitrogenous extractive matters	0·54	—
Mineral salts	0·93	1·33

The average composition of fat and lean pork is according to J. Koenig:

	Fat Pork.	Lean Pork.
Water	47·40	72·57
Nitrogenous matters	14·54	20·25
Fatty matters	37·34	6·81
Non-nitrogenous extractive matters	—	—
Ash	0·72	1·10

[1] Part of the muscular flesh soluble in cold water diluted with a thousandth part of HCl.

[2] Parts resisting water diluted with HCl, and then boiling.

The different parts of the meat of this valuable animal have not the same composition, as the following table, borrowed from Mène, shows :

PERCENTAGE COMPOSITION OF THE DIFFERENT PARTS OF THE MEAT OF A PIG.

	Ham.	Small Ham.	Chops.	Fillet.	Rib.
Water	69·60	69·32	73·00	73·15	74·11
Soluble albuminoids [1] . . .	8·80	3·77	2·08	2·12	3·01
Tendons, keratins, membranes[2]	7·10	7·15	10·46	6·00	12·80
Collagenous and waste matters	10·07	13·55	4·85	9·20	1·94
Fatty matters	8·28	5·11	8·65	8·42	7·15
Mineral salts	1·14	1·10	0·95	1·10	0·99
Total nitrogen	3·14	3·70	2·16	2·52	2·85

On reading these various tables, so much more expressive because they interpret, for the most part, the averages of a large number of analyses, we notice : 1st, the relative richness in nitrogen of beef compared with veal or mutton or even with pork. 2nd, the great variableness of the albuminoid bodies soluble in a thousandth part of hydrochloric acid and that of the indigestible residues, according to the various portions of the same animal, without the meaning of these variations in anywise characterizing the idea that we generally hold of the digestibility, easy or difficult, or of the fineness of such or such parts of the flesh of the animal. Thus, in beef, the tendons, aponeuroses, etc., amount, according to these analyses, to 11·4 per cent. in the fillet and to 8·18 only in the upper cut. 3rd, in all meats, fatty matters are very variable both as to quantity and quality. 4th, in beef, the phosphoric acid may vary from the ordinary to as much more (upper cut 2 to 1 ; shoulder 4 to 2), and more still in mutton.

At the same time as meats differ in composition, according to the parts of the animal, they also differ in sapidity. In the same animal, the flavour of the fillet, of the upper cut, of the leg, of the sirloin, etc., is different, as everybody knows. It is because the flavour of the meat depends less on its albuminoid matters than on the soluble extractive parts which accompany them, on their special fats, on the carbo-hydrates, etc., and above all on the modifications of these different substances caused by cooking. This flavour is accentuated where the fats, carbohydrates, fatty acids and phosphorated bodies are the most abundant. The matters of a basic nature called extractives such as creatin and the analogous leucomains, only contribute in a feeble degree to the sapidity of the meat by reason of their

[1] and [2]. **Same remarks as on page 132 (footnotes).**

slightly bitter taste; but one cannot say that they heighten and improve the flavour of the flesh, because the flesh of animals which have been forced or overworked, which is very rich in these matters, is not agreeable to eat.

The impression that muscular tissue produces on the gustatory papillae is especially owing to little known matters, furnished to the animal by its usual food or resulting from cooking.

Meadow pasture, especially in sea-watered meadows, or the fattening up in the stable with sweetened hay of certain regions, improves the meat very much.

The flesh which young animals (calves, lambs, kids, etc.), nourished with milk only, provide, possesses an entirely different flavour from that of the adult animal; it is developed by roasting.

Animals fattened with grains, cabbages, turnips, oleaginous oil cakes, with the residue of meat or fish, give a meat of inferior quality and often of very disagreeable taste. Everyone knows the delicate flavour of thrushes and blackbirds killed in the autumn in a country where, as in Corsica, juniper berries abound, and, on the contrary, the fishy taste of certain kinds of palmipeds (ducks, blackdivers, etc.) which feed themselves on fish from the ponds inhabited by these birds. The inhabitants of the poultry yard, particularly the hen, the turkey hen, etc., provide a very succulent and sweetened meat, when they are only given grain, especially rice. These same birds have, on the contrary, flesh of a very disagreeable flavour, if they are given oilcake or flesh in their food, as happens in the case of a fowl brought up on the waste of large towns.

The flesh of emasculated animals, whatever be the kind, is generally succulent and fat: it is easy to detect the taste of the meat of the ox compared with that of the bull; that of the capon and pullet, with regard to the cock and ordinary hen. We know also that animals in rut—a cow, bull, he-goat, ram, etc.—furnish a mediocre or bad meat, the taste of which strongly recalls the odour of the animal.

Chevreul long established the fact that rapid and forced fattening of animals for slaughter increased their fatty matters, especially in easily fusible principles (olein); their meats are more tender but less savoury, less nutritive and less stimulating, but richer in principles liable to gelatinize by cooking. I have also remarked that these meats are relatively poorer in myosin, syntonizable under the influence of hydrochloric acid, 1 in 1000, which only liquefies a small part of it. By their taste and feebler nutritive efficacy, they resemble the meat of the calf.

The best butcher's meat is that of oxen fattened on pasture land and about six to eight years old. Here are also some figures,

according to *von Bibra*, relative to the percentage composition of the flesh of young calves, older calves and young or old oxen :

	Calf, 4 wks. old.	Calf, 1 yr. old.	Young Ox.	Old Ox.
Myosin, vessels, nerves .	15·00	16·20	14·94	17·50
Soluble coagulable albuminoids	3·20	2·60	1·29	2·20
Collagenous matters . . . Extractive matters . . . Fatty matters	2·10	3·00	5·71	3·10
Water and waste matters . .	79·60	78·20	78·06	77·50
	99·90	100·00	100·00	100·30

As will be seen, myosin and the extractive matters of muscle increase with age, while water diminishes, as well as the albuminous parts—soluble in the cold and coagulable. The flesh of young animals gives up to 14 per cent. of its weight of extractives, whilst we find scarcely 1 to 3 per cent. in that of old animals. We know also the difference in the flavour of the meat of animals of the same age, according as they have or have not been exclusively nourished on milk.

Contrary to the generally admitted opinion veal, richer in principles resisting the action of acid juices, poorer in myosin, more charged with nucleins, will be then more difficult to digest than beef of good quality. The experiments of Penzoldt on digestibility seem quite to confirm these views (see p. 39), although it is always necessary to take account of the particular susceptibility and habits of each stomach. As a general rule veal should be absolutely forbidden to those who have the least tendency to skin affections, especially eczema and acne or to those suffering from affections of the urinary tract.

Meat of young animals, less rich in stimulating nitrogenous extracts, and that of birds of the poultry yard (fowl, turkey, etc.) and in general meats called *white meats*, nevertheless are regarded as being more easily digested than the red meats. This appears to apply only to the flesh of poultry. The flesh of animals which are too young is not always without disadvantages, especially that of a calf from two to three weeks old.

This flesh leaves sensibly more ash than that of beef, and this ash is more acid by reason of phosphoric acid proceeding from the oxidation of the organic phosphorus of the nucleins and of other phosphorated bodies more abundant in the meats of young animals. I give here a percentage analysis according

to Staffel,[1] deduction being made of the chloride of sodium :

Bibasic phosphate of potash	68·05
" " " soda	5·66
" " " lime	3·72
" " " magnesia	6·24
Free phosphoric acid	15·10
Silicic acid	0·20
Ferric oxide	0·30
Waste	0·73
	99·27

The ash of beef contains 1 per cent. at least of oxide of iron.

We have hitherto spoken especially of beef, veal and mutton. Pork, of which we give the composition (pp. 129 and 133), also enters in a large degree into alimentation. It is very popular in Germany. In France many families amongst the peasants eat only the salted or smoked meat of the pig, which they fatten each year by means of the residue of the farm. From the point of view of its composition, fresh pork does not differ very sensibly from beef or veal, but the meat is more compact, especially fatter than these latter and appears to be more difficult for some stomachs to digest. Pork is both firm and savoury. It requires to be well cooked and slowly masticated which makes it as digestible as beef. With respect to the diet of those suffering from Bright's disease, we shall see that it possesses a remarkable quality, that of assimilating more easily, of fatiguing the kidney of the patient less and in the case of albuminuria, or of hepatic congestion, of allowing the minimum quantity of albumin to pass by the kidney.

We shall close this chapter by giving some information on the meat of other mammals less generally eaten.

Horse flesh is used to-day by people, especially in large towns. It is consumed chiefly on account of its low price. About 10,000 horses, asses and mules are eaten annually in France.

Horse flesh has an alimentary value equal to that of beef if the animal has been well nourished, not over-driven and is not too old. Its flavour recalls at once that of beef and venison, with a slight sweetish taste due to its exceptional richness in glycogen and glucose, of which it contains, on an average, 0·5, and can give up to 4·5 per cent.

Asses' flesh is excellent ; it resembles venison. Xenophon relates that the Grecian army was well nourished by the flesh of the wild asses of Mesopotamia at the time of the retreat of the Ten Thousand.

The flesh of the mule resembles somewhat in its consistence and aspect that of beef, but it has a musky taste.

[1] Analysis of the ash of veal quoted by J. Liebig, *Letters on Chemistry*, p. 213.

Here are some analyses of these different meats, according to M. Balland (*Annales d'Hygiène et de Méd. lég.* August 1902):

	Horse—average.	Horse—leg	Ass—fillet.	Mule—fillet.
Water	74·27	73·10	76·50	74·20
Nitrogenous matters	21·71	21·95	19·14	20·18
Fatty matters . .	2·55	2·95	1·60	2·13
Extractive matters .	0·46	1·44	2·29	2·38
Ash	1·01	0·56	0·47	0·81

Venison is too well known to need any recommendation. Its taste differs sensibly from that of the meat of domestic animals, as differs that of all beasts, wild or not, which have not been directly deprived of their blood by the bleeding of the animal.[1]

Here are two analyses of venison due to *von Bibra*.

As a comparison I give the composition of this venison according to Balland :—

	For 100 parts.		
	Young Roebuck.	Full-grown Roebuck.	Kid (leg).
Muscular fibres with vessels and nerves	16·81	18·00	18·45
Soluble albuminoids . . .	1·96	2·30	
Extractive matters . . .	4·75	2·80	1·69
Fatty matters	0·50	—	1·78
Water and waste	75·98	78·83	77
Ash	—	—	1·08

We see that this flesh (and generally that of all game) is poorer in fat than that of domestic animals, and also richer in extractive matters where creatin predominates.

As the rabbit and hare also form part of our consumption, it will be interesting to know the composition of their meat. It is as follows, according to M. Balland :—

	Rabbit—leg.	Hare—leg.
Water	72·0	61·20
Nitrogenous matters . .	23·5	29·88
Fatty matters	3·14	3·34
Extractive matters . .	0·47	2·55
Ash	0·90	3·03
	100·00	100·00

[1] It is very interesting to compare the taste of a chicken bled to death or shot. In the second case the blood remains in the vessels of the animal

The flesh of reindeer, which reaches the Parisian market fairly abundantly, holds a middle place between that of venison and that of beef.

Certain kinds of dogs are fattened by the Chinese for the shambles. According to Irving, dogs were kept for the same purpose by the Indians on the upper Missouri (*Astoria*, Paris 1886, p. 122). Lewis and Clarke, in their long exploration of this country (1804–1807), relate that they existed on dog's flesh for a long time. Nansen was obliged to eat his dogs in his famous expedition to the North Pole; and all those who went through the Siege of Paris know that the meat of the street dogs proved to be sufficiently nourishing and rendered good service. It is only necessary to throw away the entrails and fat of these animals, to pickle their flesh in vinegar and spices, and to cook it sufficiently before eating it.

An examination will now be made of the forms under which the meat of mammals is consumed in general, and the result of the different preparations which it undergoes.

This will be the subject of the next chapter.

and gives to the flesh a gamey flavour and deep colour, which makes it resemble game. We also know the difference in the case of duck killed by suffocation or by decapitation.

XIII

FORMS UNDER WHICH MEAT IS EATEN : RAW, ROAST, AND BOILED MEAT—BEEF-TEA—EXTRACTS OF MEAT

BEFORE studying the meats with which birds, fish, reptiles, crustacea, etc., provide man, we shall examine the modifications and transformations which the flesh of the most customary mammifers undergoes by cooking, and the different practices of salting, smoking, drying, etc. A description will be given in this chapter of the preparations derived from these meats : beef-teas, extracts, powders, etc.

Raw meat.—Raw meat forms an excellent aliment, although it appears very seldom on our tables in this form. Cooking, employed by man from time immemorial, has the effect, on the one hand, of giving to meat an aroma or perfume which excites the appetite and provokes the secretion of gastric juice, and, on the other, of destroying the spores, germs and various parasites which are able to exist on and in meats and render them unwholesome. But in spite of these advantages, cooking—whether by roasting or by the action of boiling—has also its disadvantages.

Fick has shown that raw meat is digested three times as quickly as cooked or *even underdone roast meat.*

Cooking modifies the coagulable parts of the muscular tissue and generally makes the proteid substances more difficult to assimilate : thus dogs fed with raw bones, broken or pulverized, can bear this diet for some months without losing weight or appearing to suffer from it, whereas, if one tries to feed them with these same bones previously cooked, they die of starvation after fifty or sixty days.

The second disadvantage of cooking is that it destroys the zymases or natural ferments of this valuable aliment and causes the disappearance of the specific activity of those ferments which are capable of renewing stomachic excitation and the vital powers of invalids who cannot be nourished on roast or even underdone meat.

Raw meat is the food which agrees best with very delicate stomachs, with the tuberculous, tabetics, chlorotics and even with many children who are obliged to be weaned prematurely ; but it is necessary to know how to choose and use it methodically.

It is necessary to pay attention to the meat of sheep or of horse, rather than that of the ox, which may contain the eggs of the botriocephalus. Pig's flesh should be altogether avoided, as it is

too firm and may transmit various parasites, among others, the trichina and the cysticercus.

Meat intended to be eaten raw should be deprived of all fat, scraped and reduced to pulp with the edge of a good knife and *not chopped*. By scraping are left aside the greater part of the aponeuroses, tendons, etc. With this, pulp balls about the size of a small nut should be made, either directly and without other addition, or after having salted the meat a little, or having added to it a little cognac, rum, sugar or the gravy of cold roast meat. These balls of meat pulp *ought to be swallowed by the invalid, without being chewed*, an important condition in the case of very delicate stomachs, which can receive, in this form, up to 150 grms. of this food at a time, even when they have no appetite and are disgusted with everything and with meat in particular. Raw meat thus absorbed is easily digested. It possesses a specific activity, especially valuable in the case of consumptives, chlorotics, anaemics, weak children and many invalids whose functions it revives.

Juice of Fresh Meat—When fresh chopped meat undergoes heavy pressure (25 kgs.per square cm.) it produces from 33 to 40 per cent. of a reddish serum, filtrable through tissue paper. If the meat has been previously frozen it is possible to obtain as much as 50 per cent. of this serum. This is the nourishment that M. Ch. Richet advises for consumptives. It has little taste, is of neutral reaction and is capable of rapid change. It is possible to drink one litre and more of it per day, *when quite fresh*.[1] Mineral acids coagulate this juice. It becomes thick without discolouring at a prolonged temperature of 46° (*A. Gautier*) and the coagulation continues thus up to a temperature of 78° and 80°. Albuminous materials can be precipitated abundantly without heat from this juice by means of sulphate of ammonia.

The juice of fresh meat gives, for 1000 cc., 67 grms. of dry extract, of which 10·5 grms. are *albuminoids* ; 8·9 grms. *mineral salts* ; 47·70 grms. *undetermined extractive matters*.

The ash, rich in potassium phosphate, contains also a little phosphate of lime and magnesia as well as salt.

Cooked Meats—Beef-tea.

Meat is generally eaten cooked, roast or boiled.

Roasted meats.—Meat roasted on the grill or spit is the most savoury. Heat quickly forms on the surface, by coagulation of the albuminoids and concentration of the juices which tend to force their way out, a sort of crust which protects the underlying

[1] He calls this method *zomotherapy*. An adult should take, in order to obtain good effects, more than a litre per day of this sanguineous liquid. It should be kept on ice, especially in summer. I have tried it in the case of invalids in strong doses as indicated by MM. Richet and Hericourt, and I must say that it has not given me any very good results.

parts, prevents a too rapid evaporation of water and permits of cooking the fibre so to speak in its own juice. The odoriferous and tasty materials concentrate themselves there without the meat becoming dried up or raised to too high a temperature. Muscular tissue cooked in the oven or stove, in an enclosure at a temperature rising from 200° or 250°, resembles in look and qualities meat roasted in the open air, if the oven is large. It resembles boiled beef, if the oven is small, because the space is rapidly saturated, in this latter case, by steam.

The temperature of the deeper parts of the roasting meat varies as a rule from 75° to 85° in a fairly large piece ; it may rise from 88° to 97° at the depth of a centimetre only beneath the surface. Meat is more sensibly altered by cooking in an oven than by roasting in the open air. In both cases, but especially in the latter, the collagenous matters are in part transformed into soluble gelatine, which we again find with different tasteful products, either in the meat itself or in the juice which it furnishes.

Grilled or roast meats contain, in the dry state, nearly the same quantities of nitrogen, albuminoids, fats and salts as the raw meats from which they come. But since, after cooking, the quantity of water falls to 62 and even 42 per cent., it follows that for equal weights, grilled or roast meats are much richer in nutritive principles than raw meats (Balland).

Here is, relating to 100 parts of each, the comparative composition of the same meat raw and roast and of roast mutton and pork, according to Balland :

	Raw Beef.	Roast Beef.	Roast Leg of Mutton.	Roast Shoulder of Pork.
Water	74·5	69·9	64·10	56·40
Albuminoid substances (musculin, serin, collagens)	16·5	22·95	27·08	32·66
Albumoses and peptones . .	2·5			
Fatty matters	1·9–5	5·10	5·38	8·55
Extractive matters . .	1·5	1·04	2·04	1·08
Mineral salts	1·0	1·05	1·40	1·31

On an average, flesh loses by roasting, in the case of beef 19 per cent., veal 22 per cent., mutton 24 per cent. of its weight.

When meat is cooked in boiling water, we obtain *boiled meat and broth*. These two alimentary preparations are very different according to the method of preparation.

If we wish to obtain savoury boiled meat, it is necessary to sacrifice the broth. The meat is placed in a glazed earthen vessel, [1] of small capacity, with salt, vegetables and the minimum

[1] Iron vessels affect the taste of the meat and broth.

amount of water which will soak it. This vessel is closed with paper tied with string or even with parchment, the cover is then put on, so as to seal it as hermetically as possible. The meat is then submitted to a temperature of about 80° to 85°. At the end of 10 or 12 hours, according to the nature of the muscular tissue, a delicate boiled beef is obtained, and a liquid, which, on cooling, forms a jelly very agreeable to the taste.

Liebig, for this preparation, recommends plunging the meat into already boiling water, boiling it for a few minutes and then keeping it for several hours afterwards at a temperature of 70° or 75°. This method is by no means as good as the preceding one.

On the contrary, if one wishes (as is usually the case) to obtain at the same time boiled beef of sufficiently agreeable taste, and an adequate quantity of good beef-tea, the meat should be plunged raw into cold water which is gradually heated up to 100 ° and kept at this temperature without removing the scum and fat floating on the surface, renewing the water when necessary. By this method we obtain, after separation of the congealed parts or scum and of the fats by filtration through moistened linen, a good broth containing all the tasteful principles of the meat. The latter, on the other hand, has partly lost its taste ; it has become a little less nutritive and less easily assimilated.

To make this ordinary culinary preparation, which provides at the same time the boiled beef and broth of our households, Chevreul, in his researches on this subject, recommends taking, for a kilogramme of lean meat, 2,500 cc. of water, 18 grms. of salt and 110 grms. of vegetables (carrots, turnips, leeks, celery).

Let us investigate that which becomes, in the course of this preparation, on the one hand *boiled meat*, on the other its aqueous extract, *broth.*

Boiled Meat.—Muscular tissue yields to water about 7·5 per cent. of its weight of materials reckoned in a dry state. Three per cent. composed of soluble and coagulable albumins, remain in the scum (myoalbumin, hæmoglobin) ; 4·7 to 5 per cent. dissolve and remain in the broth. By maceration in hot water, meat loses to a large extent, its soluble and coagulable albuminoids, its pre-existing peptones, a part of the collagenous materials which the water, when warm, transforms into gelose, its soluble pigments and its ferments. Water thus takes away from the meat its basic, extractive materials or leucomains (creatin, amphicreatin, cruso-creatin and analogous bases ; only 3 to 5 per cent. of them exist in the meat), its lecithins, inosit, glycogen, lactic and inosic acids, a little taurin, finally its soluble mineral salts and a part of its fat and water.

One thousand grms. of fresh meat give about 450 grms. of boiled meat. The greater part of this loss in weight is due

to the dehydration of the meat which does not contain more than 56 to 57 parts of water in place of 74 to 75.[1]

Here is the comparative composition of meat (beef), raw and boiled, according to Balland (*C. Rend.* t. CXXX, p. 532):

	Fresh State for 100 parts.		Dry State for 100 parts.	
	Raw Beef.	Boiled Beef.	Raw Beef.	Boiled Beef.[2]
Water	74·50	56·90	0·00	0·00
Nitrogenous matters	21·67	35·28	84·98	81·86
Fatty matters	1·37	2·09	5·36	4·84
Extractive and unknown matters	1·39	4·83	5·46	11·20
Mineral salts	1·07	0·90	4·20	2·10

Thus the operation of boiling removes from the meat chiefly its sapid substances, its salts and water.

It is surprising to see that the extractive matters are more than doubled in boiled meat: but, on the one hand, the water by disappearing has concentrated them in the residue; on the other, some collagenous substances have been made soluble. Volfhügel found that the temperature in the middle of a piece of boiled beef weighing 3kgs. after boiling $2\frac{1}{2}$ hours, was 91° to 92°; and 97° to 97·5° at the depth of 2 centimetres from the surface. This proves that boiled meat is more affected by heat than roast meat.

Derivatives of Meat.

Broth—Extract of Meat.—As has been said previously, 1 kg. of moderately fat beef, without bone, or 1·300 kg. with bone, gives, under conditions we have made known, $2\frac{1}{2}$ litres of good broth, leaving 18 to 23 grms. of dry extract per litre and containing per 1,000 cc.:

Albuminoid matters	7·50	grms.	
Creatinic bases	0·9·	„	1·31
Xanthin and xanthic bases	0·25	„	
Inosic acid	0·04	„	
Taurin, etc.	0·12	„	
Inosit, glycogen	1·40	„	
Lactic acid	0·20	„	
Colouring, odorizing, etc., matters	4·60	„	
Soluble mineral salts	3·76	„	4·14
Insoluble mineral salts	0·38	„	
	19·15 grms.		

[1] According to the observations of Goubaux, lean boned meat loses in the pot, by boiling with water, from 11·6 to 29·6 per cent. of its weight.

[2] Analysed on taking it out of the saucepan.

The presence of vegetables or salt in the cooking water does not sensibly modify the weight of materials derived from the meat. A test made with 1 kg. of lean beef and 2½ kgs. of water without salt or vegetables, gave me a broth leaving 19 grms. of dry residue per litre, which corresponds per kg. of meat to 47·5 grms. of extract. A comparative experiment made with the same quantity of meat and water, but adding 7 grms. of salt per litre, 45 grms. of carrots, 40 grms. of turnips, 25 grms. of leeks and celery, gave me a broth leaving 27·3 grms. of dry residue and 20·3 grms. if one subtracted the added salt. The difference of 1·3 grms. on the extract obtained without salt or vegetables seems to be due to soluble substances brought by the vegetable matters.

Here are, according to P. Coulier, the relative weights of meat, bone, vegetables, salt, and the yield of boiled beef and broth for 100 litres of water put in the saucepan :

PRODUCTION AND YIELD OF MEAT IN BOILED BEEF AND BROTH.

	Meat with bones.[1]	Vegetables.	Salt.	Yield.	
				Boiled Beef.	Vegetables.
Civil hospitals of Paris	41·6 kg.	8·600 kg.	1·120 kg.	—	—
Formula of Chevreul[2]	37·27 „	6·620 „	0·808 „	16·360 kg	6·960 kg.
Military hospitals .	36·36 „	—	—	—	—
Duval broths . . .	35 „	6 „	0·750 „	—	—
Marine hospitals[3] .	25 „	10 „	0·248 „	—	—

According to Liebig, 100 parts of mineral matters contained in the raw meat are distributed thus in the meat and broth :

	Raw Meat.	Boiled Meat.	Broth.
K^2O	40·20	4·78	35·42
CaO;MgO;FeO . . .	5·69	2·54	3·15
KCl	14·81	—	14·81
P^2O^5	36·60	10·36	26·24
SO^3	2·95	—	2·95
	100·00	17·68	82·57

[1] We know that in the raw flesh of animals it is necessary to reckon the bones as a quarter or a fifth.

[2] Yield in broth 80 litres. The liquid is then concentrated a fifth during cooking.

[3] Yield in broth 75 litres. We shall notice that in the preparation of boiled meat and broth according to Chevreul's formula, 28·67 kgs. of fresh meat without bones, produce only 16·360 kgs. of boiled meat.

The mineral salts of broth have the following composition, calculated *per litre* of non-salted broth:

Chloride of potassium	0·72
Do sodium	0·15
Sulphate of potash	0·35
Phosphate of potash (PO^4K^2H)	2·60
Do. lime (PO^4CaH)	0·12
Do. magnesia (PO^4MgH)	0·23
Do. iron (PO^4FeH)	0·02

The albuminoid matters of broth are of two kinds: 1st, *gelatin* or *gelose*, result of the action of hot water on the ossein of the connective tissue and sarcolemma. Its quantity generally increases in proportion as the cooking is prolonged, but a part is peptonized at the same time. 2nd, the *albumins* and *peptons* due to a partial peptonization of the meat produced during the life and after the death of the animal, peptonization which the water, aided by the salts and heat, continues.

As we have just said, if we admit that the albuminoid matters of broth have the same composition as those found in Liebig's Extract of Meat (which after all is only broth concentrated in vacuo) we find that 7·5 grms. of albuminoids in a litre of broth are composed in the following manner:

Gelose	1·72 grms.
Albumoses	0·48 ,,
Peptons	5·30 ,,

It is often said (and this is one of the reasons which has made broth fall into disfavour) that this preparation is not alimentary. In reality, broth contains per litre 7·5 grms. of assimilable albuminous matters, which correspond to about 40 grms. of fresh meat. Broth is plastic also by reason of its phosphates, potassium salts and lecithins. But it especially plays the part of an exciting agent in alimentation; it is a nervine aliment (p. 264) through its gustative, odorous and sapid matters, which form about a quarter of its extract, by its leucomaines, creatinic and xanthic, tonic and bitter bases, which, in these small doses, when *they are introduced into the stomach through the mouth* (and not injected under the skin), have physiological effects comparable to those of the caffein and thein which we shall find again in tea, coffee and cocoa (*Lehmann*; *Kobert*). Like caffein and in the manner of salts of potassium themselves which accompany them, the bases of broth tone up the heart and accelerate the digestion and circulation. However, we must not forget that these bases are all poisonous in rather large doses. A guinea-pig of 410 grms. received in subcutaneous injections, several consecutive days, from 5 to 12 milligrms. of sarcin; it grew thin, passed deep yellow urine, slightly albuminous, and died at the end of 50 days. A guinea-pig weighing 408 grms. received 100 milligrms. of creatin in subcutaneous injections, its urine became deep brown and slightly albuminous. The motionless

animal cried at the least touch, soon complete anuria set in with evident prostration, and death rapidly supervened. On autopsy, an epithelial nephritis was discovered (*Gaucher*).

But unless we misuse broth and these *consommés* or concentrated broths, with which we formerly stuffed the sick and convalescent, in the small quantities in which they exist in these culinary preparations, the odorous or tasty bases and matters of the meat act only as tonics and excitants of the circulation and digestion. They are found again almost unaltered in the urine.

As for the nutritive action of broth, it is very much reduced, although actual, by reason of the small proportion of albuminoids and phosphorated extractive which it contains. Assuredly more than half the proteid bodies of broth are formed of gelatin, or of a very analogous material, and since the observations of Donné and the experiments of Magendie, the nutritive qualities of these latter substances have been subject to doubt. But if it is true that a dog fed with the gelatin of bone mixed with a little bread and meat, grew thin and succumbed at the end of sixty to eighty days, a similar animal to that which perished with the bread sop and gelatin of bone, regains its fatness and vital forces, if this gelatin is replaced by meat broth.[1]

The result of my experiments is also[2] that young animals (guinea-pigs and dogs) can assimilate the gelatinous and collagenous matters that are given them in place of ordinary albuminoids, and continue thus to nourish themselves and prosper for some months, provided that the quantities of gelatin which they consume do not reach the fourth part of the total albuminoids which the rest of their aliments furnish to them. It has already been shown that gelatin plays a protective rôle to the other nutritive albuminoids.[3]

Daily facts show that broth is a valuable adjuvant to alimentation. It momentarily and rapidly relieves the forces without the stomach having more to do than merely absorb it, and without there being any necessity for the action of the gastric juices, so often insufficient in the case of invalids. It excites the appetite and digestion, augments the gastric secretions, strengthens the

[1] See *Compte rendu*, t. XIII and XVII of the works of the Commission relating to Gelatin (1841 and 1844).

[2] "Influence of Different Preparations Derived from Meat on the Growth and Health of Animals" (*Bull. acad. Méd.* 3rd series, t. XLIII, p. 259, March 1900).

[3] It even prevents the fats from being wasted, but it could not suffice, by itself, to replace the other albuminoids of meat whatever may be the quantity given of it. If it alone is consumed, it is not sufficient, even accompanied by fats and starchy matters ; in this case, the consumption of nitrogen is always greater than that which results from the gelatin introduced (C. Voit).

heart, and slightly increases the pulse ; raises arterial tension a little and helps the work of the kidneys.

Broth can be taken at any time, during and between meals, hot or cold. It is easily digested.

We shall notice, however, that the extractive organic matters of broth belong, in a great part, to the creatinic and puric series, and that the use of this aliment sensibly increases the excretion of uric acid and similar bodies. It is, therefore, not to be recommended to arthritic, gouty and rheumatic people, or those suffering from heart disease, etc.

In various countries, for children and convalescents, a specially concentrated broth is made by cutting up beef, veal or mutton —from which the fat has been removed—into small dice, about 1 centimetre across, which are put into a large necked bottle without the addition of anything. It is sufficient, after having well corked the bottle, to heat it for twenty to thirty minutes in a pan of boiling water. Five hundred grms. of meat thus rapidly furnish 150 to 160 cc. of a tasty, very concentrated and slightly acid broth, containing 70 grms. per litre of fixed substances, of which 50 are organic matters (gelatin, albumins, peptons, lecithins, creatin, etc.). This is *bottled beef-tea.* It stimulates the heart and nervous system. It is sufficiently nourishing and should be taken in spoonfuls, in small doses at a time.

Extracts of Meat.—These extracts are made principally in South America from the meat of oxen killed in large quantities, almost solely (formerly at least) for their skins and fats. These meats give, when boiled with water, a broth which, concentrated in vacuo up to a pasty consistency, constitutes *extract of meat.* These extracts must therefore have the composition and most of the qualities and defects of broth itself.

Among these preparations the best known is *Liebig's Extract,* manufactured according to the formula of the celebrated chemist, from the meat of American oxen. It has been in great part deprived of its gelatinous and fatty matters during its preparation and concentration in vacuo.

Thirty kgs. of lean ox-meat furnish about 1 kg. of this preparation.

It is to-day met with everywhere and renders good service. Easy to keep and transport, it enables us to instantly obtain a feebly nutritive liquid, exciting and agreeable to the taste, which, boiled with vegetables and spices, can easily replace the broth of ordinary meat.

During my researches on alimentation, on muscular leucomains and the physiological action of alkaloid and saline substances of meat,[1] I have had occasion to study and analyse with care this extract of meat.

[1] Works quoted earlier.

I give here its percentage composition which I compare with that of an analogous preparation :

	Liebig's Extract (A. Gautier).	Cibils' Extract (G. Pouchet).
Water	15·26	9·904
Albumin coagulable by heat	0·05	1·012
Gelose	8·49	8·088[1]
Propeptons and albumoses	2·32	6·105 (with True peptons)
True peptons	12–26·00 (with Casein)	
Casein (precipitable by $C^2H^4O^2$)		0·658
Creatin	8·30 (Creatin, Creatinin, Carnin)	1·68
Creatinin		1·92
Carnin		2·724
Xanthin, sarcin	0·89 (with Indeterminate insoluble matters)	11·598
Indeterminate insoluble matters		
Inosit and glycogen	2·20–4·25	10·184
Lactate and inosate of potash	—	23·105
Sapid, colouring and odoriferous matters; lecithins or their derivatives soluble in alcohol at 98° centesimal	11·98	—
Soluble mineral salts	21·26	31·48 (with Insoluble)
Insoluble ,, ,,	1·13	

The mineral salts, soluble and insoluble, of these extracts are those of broth itself. A hundred grms. contain, according to M. G. Pouchet, the following salts :

	For 100 parts of extract.	
	Liebig.	Cibils.
Lactate and inosate of potash	15·451	23·105
Sulphate of potash	0·982	0·998
Phosphate of potash (PO^4K^2H)	7·352	2·686
,, soda (PO^4NaH)	6·924	8·746
Chloride of sodium	1·946	8·887
Phosphate of magnesia (PO^4MgH)	2·088	1·040
,, calcium (PO^4CaH)	0·088	0·208
Alumina and oxide of iron	0·042	0·397
Silica and *insoluble* residue in the acids	0·038	0·061
Total ash	25·141	31·481
Total nitrogen	9·57	9·43
Ammoniacal nitrogen	0·806	0·506

Thus, mineral salts in which lactate and phosphate of potassium predominate, constitute about a quarter of these preparations. This observation will deter us from the idea of making these extracts serve for direct alimentation. They should only be

[1] Syntonin mixed with a very feeble quantity of gelatin.

considered, just like broth itself, as useful excitants, digestive and nervous adjuvants, particularly of the heart and circulation. But when we have tried to nourish animals on them, the results have been deplorable, more especially when these extracts entered to a large extent into the daily ration. Thus, P. Muller (*Theses of Paris*, 1871, No. 77) has observed that when he added to his daily alimentation 30 grms. of meat extract, he was seized with diarrhoea. A dog weighing 6·5 kgs. nourished with 200 grms. of bread, 200 grms. of water, 20 grms. of fat and 20 grms. of Liebig's extract per twenty-four hours, had diarrhoea on the sixth day of this diet, and died from collapse on the ninth. But these experiments, in which the extract of meat was experimentally administered in excessive doses, which are never reached in ordinary alimentation, should not invalidate the utility of these preparations, when they are given in moderate doses, as is customary. I have made a number of experiments with these extracts, with the result that, provided they are given in a quantity not exceeding one twelfth of the weight of the total albuminoids of ordinary aliments,[1] and on condition that they do not add to the daily alimentary portion more than 2 grms. of additional potash, they are more favourable than detrimental to the growth of animals.

Other original preparations of meat exist and we can compare them with the preceding. It has been seen that these extracts contain in reality, in the soluble and nutritious state, only a very feeble proportion of albuminoids, gelatins and peptons. Already, Liebig had advised, in order to dissolve the musculin of meat, to have recourse to the action of hydrochloric acid diluted to a thousandth part with water. Five hundred grms. of lean meat are chopped up and added to 400 grms. of water, 4 drops of liquid hydrochloric acid and 15 grms. of salt. It is mixed cold, allowed to rest for some minutes, then thrown on a sieve and the pulp washed with 180 grms. of fresh water. Thus there is obtained a reddish liquid, rich in syntonin, much more nutritive than the corresponding broth, but difficult to make invalids take. It is putrescible and one cannot warm it without coagulating it. We have then tried to perfect Liebig's method. One of the preparations which is derived from it, a preparation at the same time easy to preserve, and with a rather agreeable taste of concentrated broth, and one which, taking into consideration these qualities, I have tried to experiment on animals with, is the *pepton of meat*, obtained by the method of Professor Kemmerich. It is a pasty substance and appears to me to result from the action of superheated water on beef. The analyses which I made on it in 1896, with regard to its composition, have led me to the following results :

[1] *Bull. Acad. Méd.*, 1900, loc. cit.

		Total Assimilable Albuminoids.
Water	27·83	
Gelose	10·88	45·18%
Propeptons and albumoses	9·70	
Albuminoids coagulable by heat	25·10	
Extractive matters soluble in alcohol at 98% (lecithins and phosphorous derivatives; lactic and inosic acid; odorant, sapid, colouring matters, etc.)	9·20	
Creatinic and xanthic bases	7·30	
Glycogen, inosit	1·50	
Soluble mineral matters	7·44	9·12
Insoluble „ „	1·68	
	100·00	

The mineral matters corresponding to 100 parts of this peptone weigh then about 9 grms. and contain two-thirds of their weight of potassium phosphite with 1·5 grms. of salt.

I have tried to nourish young animals with this preparation. My observations agree with those made by Pfeiffer. Provided that the proteid matters borrowed from this source do not exceed the fifth part of the quantity of albuminoids in the total ration, the animals prosper better than those receiving the small doses of ordinary alimentary albuminoids.

The *solution of meat* of Leube and Rosenthal, well known in Germany, is prepared in the following manner: To 1,000 grms. of lean meat, and without bone, we add a litre of water and 20 cc. of officinal hydrochloric acid; this mixture is placed in a closed vessel of glass and heated forty-five hours in a digester at 100°. Then the solid parts are separated and pulverized in a mortar; the liquid part is then re-added and the whole again heated for twelve hours. The liquid is then neutralized by carbonate of soda and finally is evaporated to a thick consistency on plates. Thus a sort of meat soup is obtained which can be mixed with broth or taken in spoonfuls. This preparation contains from 2 to 5 per cent. of peptons and 9 to 11 per cent. of albumins and soluble gelatins.

Other analogous industrial preparations are thus made, mixtures of fresh meat juice, partly burnt sugar and a little good wine or even cognac.

The essences and juices of meat prepared in England, Germany and America (*Fluid meat, Meat juice, Succus carnis, Fluid beef, Liquid food*, etc.) are brands well known to the medical profession.

These preparations, in general, rather agreeable to the taste, contain from 2 to 10 per cent. of soluble albuminoids together with the other components of meat extract. They are often supplemented by a little brandy, and are only essentially distinguished by their high prices.

The true *peptons of meat* are prepared by artificial digestion

of muscular tissue, either in liquid slightly hydrochloric, tartaric or citric (one to four thousandth parts) by means of pepsin or papain (*pepsic peptons*); or in water feebly alkalized by carbonate of soda in contact with pig's sweetbread well washed and cut up after the addition of volatile antiseptics (*trypsic peptons*). The products of these different digestions are then rapidly filtered through a straining bag, afterwards evaporated in vacuo, either to a dry state or to the consistence of a thick syrup. Very often a little alcohol is added to these preparations as a preservative.

Well made peptons (the good French brands are excellent) ought to have only a feeble odour of strong glue and a neutral or slightly bitter taste. The bitterness, so common in these preparations, indicates the presence of more or less dangerous alkaloids. Those which are obtained with papain or pancreatin contain also fairly considerable quantities of leucin and tyrosin; their alcoholic extract reddens diluted perchloride of iron. We cannot recommend the preparations which are advertised as particularly formed of propeptons, preparations often made with butcher's waste, the ossein of bone, etc., and which in doses of 15 to 20 grms. cause diarrhoea and fatigue, or nauseate the patient.

Besides, the works of Züntz and Pollitzer have shown that albumoses and pure peptons nourish, for equal weight, like the albumins from which they come; the propeptons do not appear by themselves to have any advantage.[1]

Deitters, confirming the experiments of Voit and Maly, establishes that, in the case of patients put into a state of nitrogenous equilibrium, up to 69 per cent. of the usual albuminoids borrowed from meat, can be replaced by their weight of good peptons without upsetting the nitrogenous equilibrium.[2]

It is not possible to give a better proof that true peptons are really assimilated.

[1] *Pflüger's Arch.* Bd. XXXVII, p. 301.
[2] *Beiträge zur Lehre vom Stoffwechsel,* Berlin, 1892.

XIV

MEATS PRESERVED BY COOKING, DESSICATION, SALTING, SMOKING OR FREEZING.

POISONOUS OR DISEASED MEATS.

MEAT being pre-eminently the most stimulating nourishment, the invigorating food of the working class and of the rich, it has from all time been preserved, either to be consumed at favourable moments or for exporting it from countries which produce it in excess to those which have not enough.

The preservation of meat is obtained by different methods; the principal being: *cooking*, *dessication*, *salting*, *smoking*, *antisepsis*, *refrigeration and congelation* or *frigorification*.

We will not enlarge on other methods but will confine ourselves only to show their results when necessary.

Meats Preserved by Cooking. The *cooking* of preserved meats is done in closed vessels, generally in tin-plated utensils from 250 to 500 cc. in capacity. It can be carried out in two ways:—(*a*) The meat is introduced raw into the utensil which is filled with concentrated beef tea. The metal cover is immediately soldered on and the temperature in the stewpan kept at 110° for a longer or shorter time according to the size of the receivers. It is then allowed to partially cool, the tins are taken from the stewpan and a hole is immediately pierced in the cover of each of these, whence the warm air and gas escape. It only remains to close this little orifice immediately by a drop of solder, then to finish the cooking. (*b*) The meat is put into tins after having been whitened by boiling, that is to say boiled some moments with water which carries off, under the form of coagulated scum, a part of its soluble albuminoids and fats. The broth thus obtained, filtered and concentrated, serves to fill the space left in the tin by the meat already boiled which has been put into it. The cover is then soldered externally and the meat submitted to a temperature of 115° or 120°, a temperature which should be maintained for a time proportional to the size of the jar, in order that the heat can penetrate the entire depth of the mass and destroy all the germs and hurtful ferments.

Billancourt's works manufacture in this way, for the needs of

the army, preserved meats which have been heated for $2\frac{1}{2}$ hours at 120°. When examined three years after, they were found in a perfect state of preservation, having the real odour of meat cooked in its gravy. Except for the consistence of its fibre which has diminished, these preserved meats have all the qualities of ordinary meat cooked in water and all its nutritive value (*Vaillard*).

It is necessary only to be careful that at the time of filling the tins, the meat is fresh and not damaged. In this case, indeed, where there has been any fermentation before cooking, the toxins already formed cannot be made to disappear, and although sterilized, the food will remain dangerous.

Here are a few analyses of these preserved meats :

	Meat preserved for the Army (analysis of an entire tin).		Preserved Beef (Austrian).	Preserved Meat (Chicago).	Meat Powder (English).
	Paris Billancourt 1899.	Toulouse, 1897.			
Water	63·06	58·94	66·20	61·35	10·90
Nitrogenous matter	26·16	22·14	20·03	26·33	66·03
Fats	8·64	16·61	12·42	9·09	3·25
Extractives . .	0·84	1·28	0·37	2·37	7·52
Ash	1·30	1·03	0·98	0·86	12·30
	100·00	100·00	100·00	100·00	100·00

A kilogramme of preserved meat, including juice, corresponds to 1,500 grms. of boned fresh meat.

1,000 grms. of preserved meat generally contains 750 to 800 grms. of meat, 170 to 190 grms. of jellified broth and 30 to 70 grms. of melted fat.

Under favourable conditions, preserved meat ought to be kept intact for five to ten years.

Every tin which smells the least bad from the outside, ought to be thrown away. The broth put in the tin should be very concentrated, otherwise it will liquefy and become turbid and give the food an unappetizing appearance.

The analysis of the tin of the boxes of preserved meats has shown that it sometimes contains a little lead ; it is the same and *à fortiori*, with the solderings where 30 to 35 per cent. of the latter metal may be found. The soldering ought then to be done externally and should never at any point come in contact with the contents of the box, otherwise a little of the poisonous metal might be introduced into the food. It is necessary to insist that the tinning of the boxes should be very white and quite bright. It is in this case free from lead.

Dessication.—Dessication is a method of preserving meat which has been practised for a long time in warm countries. The *carne*

secca or *tosajo* of the South Americans, the *kelea* or dried meat of the Berbers of the Sahara, are obtained by cutting up the meat into fine thongs and exposing it to the air and sun. The antiseptic action of sunlight is well known ; the meat dries without putrefying. It is the same with the flesh of fish : the maritime populations of the North of Europe readily enough eat the flesh of raw fish, slightly salted, put to dry on the yards of the fishing boats.

Well dried meat pulverizes easily. Powdered meats introduced into medicine for the nourishment of invalids, especially by M. Debove, are of great service when, suitably prepared, they have not undergone any commencing putrid deterioration or rancidity of their fats. Unfortunately it is not always so. Good meat powders ought to smell only of glue and roast meat. Those which leave a bad or doubtful odour should be rejected.

We can ourselves make meat powder at home : scrape to a pulp with a knife some lean meat ; dry it in a water-bath on a large metal dish slightly inclined, in order to separate the fat which melts, and then pulverize in a mortar the well dessicated matter. In this state it can be added to different broths and paps, milks etc. It is also possible, as M. Debove does, to force the powder down, diluted with a little Vals or Vichy water.

According to J. Koenig the average percentage composition of powdered beef is the following : *water*, 10·99 ; *albuminoids*, 69·50 ; *fats*, 5·84 ; *non-nitrogenous organic substances* 0·42 ; *mineral matters*, 13·25.

The *pemmican* of the North Americans and travellers in the Polar countries is powdered meat saturated with fat and mixed with salt, pepper and sugar. It is the food which possesses the maximum of nutritive powder in the least bulk. It offers very great advantages to sailors, explorers, hunters, etc., especially in very cold countries.

Salted Meats.—The practice of *salting* consists in covering the fresh meat, previously cut into quarters, with a strong layer of salt generally mixed with 2 to 3 per cent. of nitre,[1] a harmless substance in these weak doses, and which has the property of preserving in the meat its fine red colour. The muscular fibre toughens while absorbing a part of these salts, and in excreting about a third of its weight of constitutive water which carries away with it a small quantity of albuminoid and extractive matters.

At the end of 10 or 15 days, the meat is drawn out from the partly liquefied brine, then placed in casks in beds separated by layers of fresh salts, often with the addition of spices (laurel, juniper, pepper, etc.).

Here are some comparative analyses brought to 100 parts of

[1] Sometimes replaced by sugar.

beef and pork—fresh or salted. The two first are by Gérardin, the two following by Mène, the two last by M. Balland.

COMPARATIVE ANALYSIS OF FRESH AND SALTED MEAT.

	Beef fresh.	Salt Beef (from the cask).	Fresh Pork.	Salt Pork (from cask).	Salt Bacon raw, whole, cut.	The same after cooking.
Water	75·90	49·11	69	62·58	32·40	28·80
Musculin, cellular tissue	15·70	24·82	7·11	11·21	14·41	19·01
Collagenous material			10·75	2·53		
Albumin	2·25	0·70	3·80	8·58		
Fats	1·01	0·18	8·28	8·68	40·29	48·22
Extractives	2·06	3·28	—	—	0·22	0·18
Soluble salts	2·95	21·07	1·14	6·41	12·68	3·79
Losses	0·13	0·84	—	—		
Phosphoric acid P^2O^5	0·222	0·618	—	—	—	—
Total nitrogen	3	4·620	—	—	—	—
Salt	0·409	11·516	—	—	—	—

These analyses prove that salted meat, richer in assimilable parts and poorer in water than the non-salted, contains almost the whole total of the nutritive materials of fresh meat. Nevertheless, a part of its elements is passed into the brine, particularly a little albumin and some extractive matters. For 100 dry parts, natural beef contains 8·55, salt beef 6·44 only of these latter. This observation is interesting from the point of view of the alimentation of different invalids.

1,000 parts of fresh beef yield to the brine, according to Erwin and Voit:

Water	79·7 grms.
Coagulable albumin	2·4 "
Extractives	2·6 "
Phosphoric acid, especially in the form of phosphate of potash	0·4 "

and absorb 42 grms. of salt. There passes then into the brine, where the meat lies, the tenth of its soluble albuminoid matters and more than a quarter of its extractives. Finally, the salting carries off from the meat scarcely 3 grms. of proteid matters per kilogramme of meat.

Smoking.—Very often meat is smoked and salted at the same time. *Smoking* or *smoke drying* has been employed from all time by hunters and trappers as well as in the households of workmen and bourgeois, especially in wooded countries. In America, the first pioneers preserved their game by exposing it, in quarters, to the smoke of their camp fires. But the art of smoking has been particularly brought to perfection at Hamburg. The beef and smoked hams which come from there are remarkably prepared. These meats, after having been slightly salted, are

exposed for some weeks in special chambers to the cooled smoke of hearths where slow burning fires have been made of chips and dried branches of oak, fir, pine, birch and juniper. They are thus slowly charged with creosote, different pyrogenous essences and pyroligneous acid, brought by the smoke. They dry a little, become imputrescible, always preserving a part of their red colour and elasticity, and acquire an agreeable savour, whilst keeping all their nutritive value.

Here are some comparative analyses borrowed from Mène and Koenig (3rd analysis) of fresh and smoked hams :

	Fresh Ham.		Ham smoked and salted.[1]		Smoked Ham lightly salted, average.
Water	69·6		59·72		28·11
Musculin and insoluble albuminoid materials	7·1	20·97	12·61	25·07	24·74
Soluble albuminoid materials [2] .	3·8		9·16		
Collagenous and waste materials .	10·07		3·30		
Fatty materials	8·28		8·11		36·45
Non-nitrogenous materials . . .	—		—		0·16
Mineral salts	1·14		7·08		10·54

It is seen that owing to the dessication undergone by the salted and smoked meats, the albuminoid matters have increased from about 6 per cent. in proportion to the fresh meats. The assimilability of these substances and their digestibility by the stomach does not appear to be sensibly modified, an important statement which we shall make use of later on for the preparation of régimes.

Lorraine, and especially Holland and Germany, manufacture sausages, black puddings, sausages called "aux pois" sausages with chopped pork or other meats, sometimes with giblets and waste of meat, to which vegetable or cereal meals are often added. These preparations are generally salted, smoked and very spiced. Naturally their composition and nutritive value are very variable.

The following are a few of the best known analyses taken from Koenig :

	Pork Sausage.	Frankfort Sausage.	Westphalia Sausage.	"Aux pois" Sausage.
Albumins . . .	27·3	11·7	22·8	16·0
Fats . . .	39·9	39·6	11·4	39·5
Carbo-hydrates	5·1	2·3	—	29·4
Ash . . .	7·0	3·7	7·2	9·2
Water . . .	20·8	42·8	58·6	6·0

[1] Remarkably lean hams, or analyses of the very lean parts of ham.

[2] Soluble in water with the addition of $\frac{1}{1000}$ hydrochloric acid.

Antiseptic Treatment.—The preservation of meat by *antiseptics* other than smoke, does not yet seem to have given quite satisfactory results.

Creosote and carbonic acid communicate a special taste to meats recalling that of smoked meats, but more insipid and especially more disagreeable to many persons.

The use of salicylic acid has been forbidden in France (Circular of the Minister of Agriculture and Commerce, February 7, 1881) because this agent is not tolerated by all stomachs, nor always easily excreted by the kidneys : in doses where it is advantageously employed to preserve meat, some accidents have occurred.

Borax in solution has been rejected for the same reason and also because it sometimes contains lead. A trial has been made to powder meat, by means of bellows, with a mixture called *preservation salt* composed of 100 parts borax and 0·25 parts of salt.

Formol possesses a very powerful antiseptic action, but its combination, even in a very feeble proportion, with the albuminoids, renders these latter indigestible or very difficult to digest.

An attempt has been made to preserve meat in an atmosphere of sulphurous acid, or to render it imputrescible by the addition of alkaline bisulphates. These bisulphates alter its fibre. The composition of meat thus treated is sensibly modified by contact with an antiseptic (A. Riche ; Masson, publisher, 1897).

In England, Scollay and afterwards Gamgee have proposed to inject into the veins of the animal carbon monoxide immediately after its death, or to asphyxiate it by this gas. In the latter case, the cut up meat is afterwards left for eight days in contact with this same carbon monoxide which has been mixed with sulphuric acid. Cooking afterwards removes these antiseptic gases from the meat which has now become imputrescible.

The only practical means up to the present of preserving meats by antisepsis consists of salting them, exposing them to smoke or to very strong spices.

Refrigeration and Congelation.—The last process and the best to preserve meat is the action of cold. Different from the preceding preserved meats, which always end by producing satiety or of which the savour is modified by salting or smoking, spices, etc., *refrigerated* or *congealed* meats keep almost in the state in which they were at the moment when the animal was killed. They may entirely replace ordinary meat.

The preservation of meat by cold has been in use for a long time, but it is necessary to distinguish between meat simply *refrigerated* and *frozen meat.*

In *refrigeration* meats are preserved in a cool chamber towards 0° C. They can only be kept thus with advantage during one or two months at the most.

In an interesting report made to the Academy of Science on the methods of Tellier for the preservation of meat by *refrigeration*, Bouley, in 1874, wrote[1]: "It is not necessary that the cold chamber where the meat is preserved be rigorously maintained at 0° C. Experience has proved that the temperature may oscillate between + 3° and − 2° C. The large pieces can remain quite as much imputrescent in the freezing chamber as the medium or little pieces. . . . The duration of the preservation of organic matter in the cold chamber *can be considered as indefinite from the point of view of putrescibility*, but it is not quite the same *from the comestible point of view*. In proportion as the time of preservation is prolonged, the tenderness of the meat is increased gradually and, towards the end of the second month, their savour gives place to a sensation which reminds one of fatty matter (p. 743)."

These observations by Bouley have been confirmed by Poggiale and by the Technical Commission charged, in 1889–90, by the Minister of War, to study the best conditions of preserving meat destined for the revictualling of the troops and entrenched camps. Not only does the refrigerated meat gradually change in taste, but as soon as it is no longer maintained at 2° or 3° C. in the ordinary air, it becomes covered with mould ; and in dry air, it becomes smoked, dried up and blackened.

Things happen otherwise if, as is done in the large American establishments of La Plata or the Argentine Republic, the meat, as soon as the animal is killed and cut up, is carried into chambers maintained at − 10° or − 12° C. These meats, after having been rapidly frozen to the centre, are quickly placed in freezing chambers at − 5° C. Practically, in these conditions, they preserve all their qualities ; after six months or more, when they are allowed to thaw slowly in the air, they again take on a bright red look, the elasticity and nearly the same taste that they had at the time of their introduction into the refrigerating chamber. To-day, thanks to this industry, the pampas of South America, Australia and New Zealand provide Europe with a part of the supplementary meat which is necessary to it, and in a very satisfactory way. In 1894 England alone received from America 833,000 cwt. of mutton and beef thus refrigerated and almost as much from her colonies Australia and New Zealand. In France the importation of these products does not yet exceed 25,000 metric cwts.

It is scarcely probable that the freezing and preservation of these meats sensibly modifies their composition, except in making them lose a little water or perhaps in allowing their soluble ferments to act slowly on the muscular fibre. In order to satisfy myself, however, and to reply to the questions raised from the

[1] *C. rend.* t. LXXIX, p. 739.

point of view of public health on the employment of this meat, as well as on the attempts to introduce this valuable food into the victualling of camps in time of war, I have made a comparative analysis of mutton and beef fresh on the one hand, and frozen, for eight to nine months, on the other. Here are the results:

COMPARISON BETWEEN FRESH AND FROZEN MEAT.

Composition for 100 parts.	Fresh Mutton (shoulder).	Frozen Mutton (shoulder (5–6 mos. at – 5°).	Fresh Beef (rump steak).	Frozen Beef (5–6 mos. at – 5°).
Water	74·92	73·66	74·75	73·96
Globulins with a little albumin corresponding to the part of the meat soluble in water	3·32	2·14	3·06	2·69
Peptones	1·33	1·29	2·24	2·56
Myosin	8·31	10·33	10·96	9·29
Myostroin	4·49	4·04	4·30	6·41
Indigestible matters (keratins, elastins)	0·86	0·75	0·24	0·94
Extractives, ferments, leucomaines	0·49	0·95	0·97	1·01
Glycogens	0·40	0·03	0·38	0·16
Fats and cholesterins	5·23	5·38	1·98	2·04
Soluble mineral salts	0·60	0·53	0·65	0·47
Insoluble ,, ,, ...	0·65	0·44	0·44	0·44
Total	100·52	100·24	99·96	100·02

Further, for 100 grms. of these two kinds of meats, I have found:

	Fresh Meat.		Frozen Meat.	
	Mutton.	Beef.	Mutton.	Beef.
Dry extract of parts soluble in cold water .	5·84	6·92	5·34	6·99
Dry extract after coagulation by heat of the albumins and globulins	2·52	3·86	3·20	4·50
Dry extract of broth obtained by ebullition (8 hrs.) of meat minced with an excess of water	3·37	3·98	3·62	4·17
Gelatinizable parts of the meat by heating at 115° the residue insoluble in water	2·72	2·56	2·69	[illegible]·15
Nucleinic acids	0·56	0·44	0·591	0·66
Reducing matters of meat calculated in Glucose	0·191	0·24	0·171	0·1

The results from the whole of these determinations are :—

1st. Meats frozen and preserved for some months from 3° to 5° contain about 1 per cent. of water less than the good butcher's meat of our country left one to two days in the open air.

2nd. In 100 parts in weight of these frozen meats we find for the total of digestible albuminoids :

	Soluble Parts.	Insoluble Parts.	Total.
For mutton . .	3·13	15·27	18·70
For beef . . .	5·25	15·70	20·95

The assimilable albuminoids are a little more increased in these meats than in fresh meats :

	Fresh Meat.	Frozen Meat.
Mutton	17·45	18·70
Beef	20·56	20·95

3rd. Far from being more gelatinous than fresh meat, as has been stated, the congealed meats are rather a little less.

4th. As to composition and weight, the fat matters are equal in the fresh and frozen meats : but in the latter, they take a slight taste of tallow, which allows these meats often to be recognized even after roasting.

5th. The extractive matters are not sensibly more abundant in the frozen meat, glycogen excepted. But this latter seems to disappear little by little during preservation.

6th. Contrary to that which one would have feared from a gradual and slow alteration of the albuminoid matters by the natural ferments of the tissues, the leucomaines proportioned to the state of phosphomolybdates (allowance being made for the peptones), have been slightly less abundant in the frozen meat than in the natural meat.

7th. The peptonized parts of these meats have not sensibly varied during freezing :

Peptones in 100 parts of Meat.	Frozen Meat.	Fresh Meat.
Mutton	1·33	1·29
Beef	2·24	2·56

8th. When, before consuming it, this meat is allowed to reach the ordinary temperature, it produces there, under the action of its own ferments, a fairly rapid partial peptonization which contributes to the formation of an exudation more abundant than that produced by fresh meat; this has led to the belief that frozen meat has a greater power of alterability or putrescibility. It is supposed that by the act of freezing the cells of the fibre break and allow, at the moment of thawing, their contained liquid

to run out. This is quite an erroneous opinion. Dr. Letulle, who has made, in the refrigerating chamber itself, a careful microscopic examination of the sections of the muscular fibre thus congealed, has stated that it is perfectly intact, and that one does not see in it either ice crystals or lacerations of the fibre of any kind.

9th. The flavour of frozen meat, when it is cooked, differs by a slight taste of burnt fat from that of ordinary meat. Boiled frozen meat is excellent and difficult to distinguish from ordinary meat.

10th. Finally, I am sure that the digestibility of these meats by the gastric juice of the dog, or by a mixture of active pepsin and hydrochloric acid in a thousandth part, is identical with that of natural meats.

As for their preservation, a slice of natural beef left in free air at 12° to 18° in the spring remained 198 hours without any disagreeable odour ; a similar slice of frozen meat acquired the odour of tainted meat at the end of 92 hours only. But there is a great gap between this and the assertion so often expressed that frozen meats *putrefy immediately after being thawed.* As a matter of fact, these meats can remain several days in the air, be loaded in wagons, transported pell-mell over several hundred kilometres, even in summer,[1] without any signs of putrefaction appearing.

It was important to establish these different facts from the point of view of the practical use of these meats, especially by the army, their transport by rail over long distances from the places where they were frozen and stored, their consumption only at the end of several days, and the possibility of provisioning forts with them. These verifications are the chief result and origin of the long work that I have carried out on this subject and which I have rapidly recapitulated.[2]

MEATS FROM DISEASED ANIMALS.—POISONOUS MEATS.

The meats of animals afflicted with infectious diseases can transmit these diseases if the mouth and digestive tube of the persons consuming them are not healthy, and especially if these meats are not well cooked. But, strangely enough, experience has shown that it is possible to eat almost with impunity the cooked flesh of mad animals (Decroix) and those suffering from glanders, typhus, tuberculosis (Bollinger) without contracting these diseases. It naturally constitutes a defective and even dangerous alimentation if care has not been taken to *thoroughly well cook* the meat, *above all, to have it well boiled* ; but if this pre-

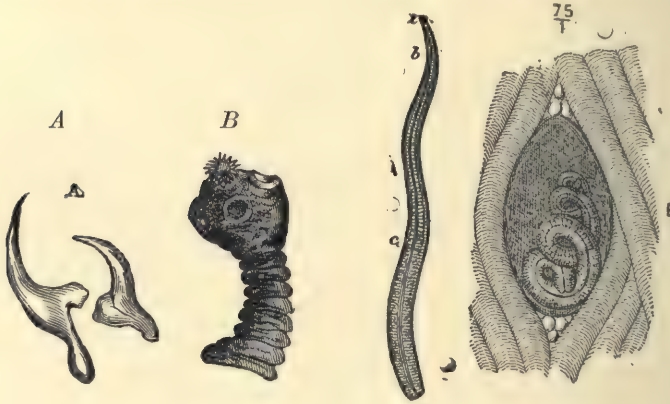
[1] Provided that they are transported in large quantities at a time and directly after they are taken from the refrigerating room.

[2] See my memoir on "Fresh and Frozen Alimentary Meats" in *Revue d' hygiène* de Vallin: April and May 1897.

caution is taken, the consumption of these meats is not as a rule followed by accidents.

Animals affected with carbuncles have often been eaten during famine, and the spores of the bacteria, which are nevertheless remarkably resisting, have very rarely transmitted the carbuncle, because these spores are only produced after the death of the animal *in the parts exposed to the air*, where the action of heat is then generally sufficient to kill them.

The meat of animals afflicted with typhus or pest is tainted, flabby, brownish and damp. Even after well cooking, it evidently seems wiser to avoid it. It is the same with the flesh of



Head and hooks of the bothriocephalus.

Trichina encysted in the muscular bundles.

FIG. 4.

overdriven animals, those slaughtered in a state of fever or madness. They taste doubtful and cause diarrhoea and sometimes provoke poisoning.

Actinomycosic meats must also be avoided; those which contain, as often happens in pork, cysticerci or trichinæ (Fig. 4, *on the right*). Pike, salmon, fresh water herring, lote in certain regions (Lakes of Geneva, Annecy, etc.) also contain cysticerci and produce special toenia (Fig. 4, *on the left*).

The meats which have begun to turn putrid are particularly unhealthy. They then not only contain very venomous ptomaines (collidin, hydrocollidin, cholin, neurin, tetra and penta-methylene diamines), but also toxic albuminoids or toxins whose action on the digestive tube causes, sometimes at the end of two or three days only, serious enteritis which often proves fatal (Botulisme).

The meats of very young animals may sometimes act as purgatives.

XV

MEATS OF WILD MAMMALS—MEATS OF BIRDS—INTERNAL ORGANS AND BLOOD—FISH

ALIMENTS FURNISHED BY THE INVERTEBRATES.

MEATS of Wild Mammals.—The hare, rabbit, deer, wild boar, etc., provide us with a certain contingent of alimentary meats. In general, the flesh of wild animals is more indigestible than that of the animals of the shambles, less fat and stronger in taste. The straining of the animal when it has been hunted before its death, and the non-extravasation of its blood are conditions which essentially modify the tastes of these meats. They are often more savoury, richer in extract, more stimulating, more coloured, harder to the teeth, generally more difficult to digest than butcher's meat, even when it is made tender by keeping it and allowing it *to get high* or pickling it. Game constitutes then an exceptional alimentation, very stimulating for people—healthy or otherwise. It is liable to cause intestinal troubles, cutaneous eruptions, hepatic and renal congestions, etc.

We have given (p. 115) some analyses of these meats.

Meats provided by Birds.—The flesh of birds of the poultry yard, the fowl, turkey, guinea-fowl, pigeon, duck and goose, placing them in the order of their decreasing digestibility, contribute in a sensible degree to our ordinary alimentation. Pigeon constitutes a heating nourishment ; its meat is rich in extract, in phosphoric bodies, in principles furnishing uric derivatives. Duck produces a very variable flesh according to the kind. Wild duck often furnishes an abundant and odorous fat with sometimes an unpleasant fishy taste. Goose is tough except when young.

Here are some summary analyses of these bird meats ; the three first are due to Von Bibra. In the two others, due to M. Balland, the composition of goose flesh before and after roasting has been set forth :

	Fowl.	Wild Duck.	Pigeon.	Fat Goose.	Roasted Goose.
Muscular fibre, vessels, tendons, etc.	16·50	17·68	17·00	14·24	26·82
Soluble albuminoids . .	3·00	2·68	4·50		
Collagenous matters	2·60	1·23	2·50	0·58	3·04
Extractive "		4·12			
Fats	very variable	2·53	variable	18·85	17·29
Water and losses . . .	77·30	71·76	76·00	66·00	51·90
Ash	—	—	—	0·33	0·95

I have given other analyses of these meats (goose, turkey, partridge and thrush) in the general table on p. 115.

White, Red and Black Meats.—We often classify the meats in *white, red* and *black* groups and we admit *à priori* that the white are lighter to the stomach ; the black are more exciting and more difficult to digest. In reality, white meats (gallinacean, veal, venison, lamb and fish) are most often less succulent than the black meats of wild animals, which above all owe their deep colour to the fact that they have not lost their blood the moment they have died. But certain white meats, those of veal, venison, rabbit, for example, are more difficult to digest than the red meats of beef or mutton, at least where there is an equal quantity of fat. White meats contain nearly as much extractive material, and some, in spite of their colour (rabbit, veal, venison, pigeon) are very rich in nucleins and produce more uric acid than the red meats, if not more than the black. Besides, the same animal, the rabbit or fowl, for example, furnishes white or red meat according to its various parts. The relation claimed between the colour of the meats and their digestibility is then very arbitrary. Save for wild animals, whose meats are more charged with extract, more stringy, less rich in fat, more exciting, more savoury, and amongst whom the blood is not extravasated at the moment of death, more or less colouration of the meat is not a sign of its lesser or its greater digestibility.

INTERNAL ORGANS.

Warm blooded animals provide for our alimentation, besides their muscular tissue, various accessory parts which we include under the general term of internal organs. Some are almost entirely muscular, such as the heart ; others differ more or less from meat in their composition, such as the liver, lungs, cerebral tissue, etc. Some practical indications on these accessory aliments of animal origin will be of some use here.

The Heart.—It is a fibrous meat, of mediocre taste but very nutritious and furnishes an excellent broth. Here is given the

average percentage composition in relation to the meat taken from the same animal:

	Meat from Upper Cut of Beef.	Heart of Same Ox.	Heart of Ox (average).	Heart of Sheep (average).
Nerves, tendons, fibres	8·18	17·10		
Albuminous matters soluble in water acidulated with HCl (1 in 1000)	2·72	2·42	19·60	17·65
Collagenous matters	6·10	8·86		
Fatty matters	9·60	2·30	13·7	5·73
Mineral salts	2·00	0·57	0·88	0·91
Water	71·40	68·75	56·7	75·1

These analyses show the excess of fibre, tendons, etc., found in cardiac muscle; its poorness in fatty material and salts; its richness in collagenous substances liquefiable by boiling in water. The heart is rich also in glycogen and nucleins.

The Spleen.—The flesh of the spleen is very little sought after. Its mean composition is, according to Kœnig:

	Beef.	Pork.
Nitrogenous matters	19·87	15·67
Fatty matters	2·55	5·83
Non-nitrogenous matters	0·17	2·84
Ash	1·70	1·42
Water	75·71	75·24

The assimilable portion of this organ is provided chiefly by the globulins and nucleo-albumins; one of them is very ferruginous. The loose framework of the spleen is filled with close malpighian corpuscles containing white and red globules in the process of transformation, accompanied by numerous extractive materials—sarcin, guanin, xanthin, lecithins, tyrosin, leucin, cholesterin, etc. In conclusion this flesh is only a very bad aliment.

Kidneys.—Their flesh is excellent when they come from very young herbivorous animals; but these organs are bad when they come from old or carnivorous animals. In the first case they constitute a very nourishing aliment and easy to digest. Gottwalt[1] has found there 1 to 1·5 per cent. of serin; 8 to 9 per cent. of globulins and nucleo-albumins; 1·5 per cent. of a sort of casein; 4 to 5·5 per cent of collagenous and undetermined substances. Sarcin has also been traced in it (0·068 per cent.), as well as inosit, taurin, a little cystin, lecithins, etc.

[1] *Zeitsch. physiol. Chem.* t. IV, p. 431.

Here is the composition of the kidneys of some comestible animals :

	Veal.	Mutton.	Pork.
Nitrogenous substances	22·13	16·56	18·14
Fats	2·77	3·33	6·69
Non-nitrogenous extractive	—	0·21	—
Ash	1·25	1·30	0·97
Water	72·85	78·61	74·20

The Liver.—This is a good aliment if it is taken from young and healthy animals ; but it needs sufficient cooking to destroy the infectious germs which it may contain. In it are found specific soluble proteids, coagulable at 45°, 50° and 56° ; a kind of myosin, a globulin ; a nucleo-albumin coagulable at 70 to 71 ° ; some savoury and phosphorated fats and lecithins which, in *foie gras* can exceed 30 per cent. of the total weight of the organ ; finally glycogen, varying in proportion according to the mode of alimentation and the race of the animal, from 1 to 16 per cent. Liver contains besides a ferruginous pigment, hematogen, relatively abundant in the case of new born animals.[1] The liver of young animals is also easily assimilable and as nutritive as meat.

Here is the percentage composition of liver according to Von Bibra :

	Beef.	Veal.	Mutton.	Pork.
Water	71·4	72·80	69·25	71·16
Insoluble parts	11·3	—	—	—
Soluble albumins	2·4	17·60	18·18	18·61
Collagenous matters	6·3			
Fatty matters	3·3	2·39	5·24	8·32
Extractive matters	4·9	5·47	6·20	—
Mineral matters	1·0	1·68	1·13	1·91

The mineral matters of liver are especially rich in phosphates of potash and soda.

Lungs.—The lung (commonly called " lights ") is a very little esteemed food, although fairly nutritive. It contains in the case of beef and mutton from 8 to 15 per cent. of nitrogenous materials, partly assimilable, formed especially of cartilage, elastin, mucin, keratin, with leucin, taurin, guanin and uric acid, etc., in which this parenchyma is very rich. These substances greatly

[1] Calf's liver contains 0·18 grms. per cent. of iron at birth, and only 0·032 grms. after some weeks.

diminish its alimentary value.[1] However, cats and dogs easily digest this aliment.

Brains, Marrow.—Cerebral material is essentially formed of nitrogenous and phosphorated fats (lecithins) free or united with albuminoids (protagons), with ordinary fats (olein, margarin, stearin) and a sort of casein or globulin easy to digest and very nutritive. This composition resembles to a great degree the cerebral material of the yolk of an egg. It contains from 70 to 80 per cent. of water.

The following is the composition, according to Balland (*loc. cit.*), of calf's brain (scalded):

Water	69·10
Nitrogenous matters	13·26
Fatty matters	16·33
Extractive matters	0·12
Ash	0·19
	100·00

We find 0·2 to 0·7 per cent. of mineral salts in the brain formed chiefly of phosphate of potash and sodium chloride.

As inutilizable substances, the nervous material contains a sort of keratin, some cholesterin and puric bodies.

The spinal marrow is almost similarly composed.

While possessing a very different constitution, bone marrow contains as much as 97 per cent. of fatty substances rich in phosphorated lecithins. That of young animals pounded raw in cold water, gives a thick reddish liquid which appears to have been administered with success in cases of anaemia and chlorosis (Damford, Fraser, Ehrlich).

Sweetbread or Thymus.—Sweetbread excels in its easy digestibility. It is, above all, composed of special assimilable albuminoids and of some fats, phosphorated or not. Here is its rough percentage composition: Albuminous substances, 22; collagenous substances, 6; fats, 0·4; salts, 1·6; water, 70 per cent.

Skin; *Head*; *Lard.*—The soft parts of the derma are all comestible. The skin, head, ears and feet contain a certain quantity of muscular fibres, of assimilable albuminous materials, of cellular tissue more or less rich in fat, elastic and connective fibres. These latter, by cooking in water, are transformed into a gelatinuous material very rich in nucleins. It is also necessary to avoid giving these aliments to gouty people and arthritics.

Skin with its cellular sub-layers charged with fatty bodies (especially in the case of animals submitted to forced fattening), forms lard. It has, like pork, the following composition with

[1] Composition of calf's lights according to Balland: Water, 78·00; nitrogenous matters, 16·36; fatty matters, 1·63; extractives, 2·65; ash, 1·36 per cent.

which we will compare that of the same aliment kept after salting, and as it is usually eaten :

	Lard in its Natural Form.	Lard Salted.	
Water	69·55	62·58	9·15
Fatty matters	11·77	8·68	75·75
Soluble albuminous materials .			1·13
Collagenous substances . . .	23·31	22·32	0·71
Aponeurosis and fibres . . .			7·28
Mineral salts	1·10	6·42	5·98
	Gérardin (lean animal)	C. Mène	C. Mène

These analyses are certainly not applicable to a series of previous deductions which may be compared ; the third in particular, relates to lard with all its fat.

Lard is a rather heavy aliment, but sought after for the savour which it communicates to vegetables. It accompanies and forms a good addition to dry vegetables.

Blood.—Blood, especially that of the pig, is utilized under different forms in alimentation (blood saveloys, black pudding, swedish blood bread etc.). It contains in the natural state, according to the kind, from 77 to 84 per cent. of water ; 8 to 16 per cent. of a ferruginous albuminoid substance, hæmoglobin 3 to 8 per cent. of serin and globulin (albuminoids of the plasma) 0·12 to 0·20 of fibrin ; from 0·12 to 0·30 per cent. of different fats and from 0·7 to 1·3 per cent. of mineral salts rich in phosphates.

It is a difficult aliment to digest and assimilate. It should only be consumed mixed with lard and other fats and after being well cooked, because it rapidly changes and may, even in the fresh state, contain infectious germs.

Here is a summary of the composition of the blood of a few comestible animals :

PERCENTAGE COMPOSITION OF THE BLOOD OF COMESTIBLE ANIMALS.

	Ox.	Cow.	Calf.	Sheep.	Pig.	Rabbit.	Fowl.	Goose.	Horse.	
									Venous. blood.	Arterial. blood.
Water . . .	79·6	78·8	83·6	79·8	76·9	81·73	78·50	81·49	81·5	81·98
Red corpuscles .	12·3	12·6	9·25	10·2	14·6	17·07	15·1	12·14	9·87	9·67
Soluble albumins	6·5	6·7	5·53	8·5	7·29		4·72	5·08	8·12	7·81
Fibrin	0·54	0·63	0·41	0·32	0·39	0·38	0·51	0·35	0·50	0·53
Fats	0·22	0·22	0·13	0·18	0·19	0·19	0·23	0·26	—	—
Extractives . .	—	0·20	0·30	0·20	—	—	0·10	—	—	—
Ash	0·87	0·98	1·09	0·98	0·79	—	0·90	0·80	—	—
Authors . .	Poggiale				H. Nasse		Poggiale		Clément	

FISH.

Fish has formed and still forms, the sole animal nourishment of certain people called *ichthyophagists.* If the Latin and Saxon races consume relatively a small amount of fish, those of the coasts of Northern Europe and Northern Asia nourish themselves on it almost exclusively. The Chinese and Japanese eat scarcely any butcher's meat; fish with rice, and sometimes a little pork and poultry, constitutes the groundwork of their alimentation. The flesh of fish is less nutritive than that of herbivorous animals, it contains less strengthening power. It is perhaps less universally supported by the majority of stomachs than ordinary meat. It is said to be slightly aphrodisiac. In some people it brings on nettlerash and eczema ; it is not altogether satisfactory for the gouty or arthritic and those suffering from diseases of the kidneys and bladder, etc., etc. But, except in the cases of certain very fat fish, as the eel or salmon, this flesh is equally if not more easy to digest than that of herbivorous and gallinaceous animals.

It is besides very different according to the species from which it comes, and in the same species, according to the time of year and the place in which the fish live. The proportion of their fat varies enormously (from 0·14 to 30 per cent.) It is liquid and contains from 50 to 65 per cent. of olein rich in special phosphorated matters.

The flesh of fish impregnates itself sensibly with the odour of the places in which they live. The difference in taste of mullets from the high seas is distinguishable from those which are nourished in pools and fishponds with stagnant water. The same kind of fish may become poisonous in certain places on the coast or at certain seasons only, as happens in the case of the horse mackerel fished for at Guadeloupe, the scorpena of St. Domingo, the fugu of Japan. It is well known how rapidly fish loses its freshness ; the least alteration in its flesh may give rise to itching, eczema and sometimes diarrhoea.

Here are some analyses of the flesh of several common fish. They are due to M. Balland [1] and relate to 100 fresh parts :

Analysis of the Flesh of Fish in a Fresh State. (According to M. Balland.)

	Shad. S.R.[2]	River Eel. R.	Pike. R.	Carp. R.	Gudgeon. R.	Trout. R.
Water	63·90	59·80	79·50	78·90	81·20	80·50
Nitrogenous matters [3]	21·88	13·05	18·35	15·71	15·94	17·52
Fatty matters . .	12·85	25·69	0·66	4·77	1·03	0·74
Extractive matters .	0·11	0·70	0·41	0·08	0·44	0·44
Ash	1·26	0·76	1·08	0·54	1·39	0·80

[1] *C. rend.*, t. CXXXVI, p. 1,729.

[2] S.R. = sea and river fish ; R. river fish ; S = sea fish.

[3] Calculated by multiplying their total nitrogen by the constant coefficient 6·25 ; which evidently only gives an approximation.

	Salmon. S.R.	Sole. S.	Mackerel. S.	Cod. S.	Fresh Herring. S.	Skate. S.
Water	61·40	79·20	67·60	84·20	76·00	76·40
Nitrogenous matters [1]	17·45	17·26	15·67	13·87	17·23	22·08
Fatty matters . .	20·00	0·81	15·04	0·14	4·80	0·45
Extractive matters .	0·08	1·11	0·28	1·00	0·46	0·17
Ash	0·87	1·62	1·41	0·79	1·51	0·90

These figures show the variableness of the composition of the flesh of fish, in which water can rise from 59 to 84 per cent., the nitrogenous matters from 13 to 22 per cent. and the fatty matters from 0·14 to 25 per cent. and more.

The numbers given above relate to the pure flesh. But in the calculation of an alimentation for supplying a family, a college, an administration, etc., it is necessary to take into account the waste matters—fish bones, fins, head, entrails, scales, etc. They reach, according to Payen, to 24 per cent. for the eel, 32 per cent. for pike, 37 per cent. for carp, 9 per cent. for salmon, 22 per cent. for mackerel, 19·2 per cent. for skate, 40·9 per cent. for whiting, etc. On an average 26 per cent.

From these analyses we conclude: 1st, that for the flesh of fish, the quantity of nutritive nitrogenous matter is generally less, by from 2 to 4 per cent., than in the case of mammals; 2nd, that the proportion of fat, as well as the nature of these fatty bodies, is very variable in the case of fish; 3rd, that the matters called extractives are much less abundant in fish than in the case of beef. The flesh of less fat fish (pike, dab, whiting, cod, perch, skate, sole, tench, weever) is also the most nitrogenous and best digested.

There is no connexion between the composition of the flesh of fish of the same group.

In these animals the mineral matters are more abundant and richer in chloride of sodium for sea-water fish, and in potassium phosphate for fresh-water fish. Here is an example:

Per cent. of ash.	Haddock (sea-water).	Pike (river).
Potash (K^2O)	13·84	23·92
Soda (Na^2O)	36·51	20·45
Lime	3·39	7·38
MgO	1·90	3·81
P^2O^5	13·70	38·16
SO^3	0·31	2·50
Cl	38·11	4·74
Weight of ash for 100 parts of flesh	11·26	6·13

[1] Calculated by multiplying their total nitrogen by the constant coefficient 6·25; which evidently only gives an approximation.

By cooking *in water*, the flesh of fish loses a part of its soluble and extractive substances and becomes less exciting and a little less nourishing. That of thin-fleshed fish (sole, whiting, pike, perch, etc.), when it has been boiled, forms a plastic aliment which though light to digest, introduces into the system only a minimum of extractive exciting matters. It agrees particularly with convalescents.

With fish and blood dried and pulverized, mixed with salt, flour, and spices, preparations are made in Sweden, rich in proteid bodies (70 to 80 per cent.), and which are very nutritive and at a price sufficiently low to contribute usefully to the alimentation of the people.

We eat a large quantity of salted or smoked fish—salted cod, salted or smoked herring, salted and smoked salmon, etc. These aliments are very rich in albuminous materials, and being relatively cheap, are able to render good service. It is better to get rid of the excess of salt by soaking the fish in pure water before cooking.

Here are some analyses of these aliments :

Centesimal Composition of some Salted or Smoked Fish.[1]

	Dried Cod (average).	Salted Cod (average).	Salted Herring (average).	Salted and Smoked Herring.	Smoked Salmon.	Sardines in Oil (flesh).
Water	16·16	13·20	46·23	34·38	61·78	56·30
Nitrogenous matters	81·54	73·72	18·90	36·76	20·16	23·21
Fats	0·74	3·37	16·89	15·74	15·68	14·07
Non-nitrogenous matters	—	—	1·57	—	—	2·27
Mineral salts . . .	1·56	9·92	16·41[2]	13·12	2·38	4·15
Authors . .	Almen Atwater	A. Almen	A. Almen	Atwater and Woods	Atwater and Woods	Balland

It is well known that there are certain parts of some fish which are or may become poisonous ; such are the eggs of barbel, pike, loach and conger eel. It is their flesh and eggs which are toxic at the time of spawning, as the fugu (*Tetroden rubripes*) of Japan and the *Meletta thrissa*. Others have a flesh freely poisonous at all times, although they may be excellent to the taste, such as the majority of the animals belonging to the *Tetrodon* and *Diodon* species, the boelassa anchovy of the rivers flowing into the Indian Ocean, the guiet, the false horse mackerel, the ostracean or trunk fish and the toad fish of the Cape. The signs of these poisonings, generally very rapid, are : reddening of the tongue, vomiting, diarrhoea, articular pains, dysuria, pruritus, irritation of the

[1] According to J. Kœnig, *loc. cit.*   [2] 14·5 of salt.

throat, dilatation of the pupils, hardness, frequency and smallness of the pulse, state of syncope.

ALIMENTS FURNISHED BY THE INVERTEBRATA.

Reptiles, crustacea, gasteropods, cephalopods, molluscs and radiata also furnish a certain number of aliments.

The flesh of snakes is consumed in some poor countries in the guise of eel's flesh. I refer to it here, because it may be poisonous if badly cooked.

The turtle gives a gelatinous flesh, dense and rich in fat, rather sought after. The eggs of these animals are consumed in great numbers on the river banks of South America, where these animals abound. They are even dried and their powder hawked about.

The legs of the frog form a very acceptable dish, recalling the flesh of fowl but more easily digested. It is an aliment to be recommended to convalescents and to those with delicate stomachs.

M. Balland has found for 100 grms. of this flesh:

Water	78·40
Nitrogenous matters	18·45
Fatty matters	0·47
Extractive matters	0·44
Ash	1·24

On the contrary, edible snails, used in rather a large number in some countries as an aliment of taste, give a rather indigestible flesh which ought to be strongly seasoned in preparation. The most appreciated are the vine or Burgundy snails (*Helix pomatia*), the *Helix sylvatica* of Southern France, the *H. aspersa, vermiculata, variabilis*, etc., which they eat very much seasoned or with vinegar sauce, etc. Here is the composition of Burgundy snail according to M. Balland:

	Non-discharged.	Discharged in Salt Water.
Water	85·00	81·00
Nitrogenous matters	10·11	14·27
Fatty matters	0·72	0·83
Extractive matters	2·61	2·46
Ash	1·50	1·44

Oysters are the most sought after of the number of aliments of luxury. In France the *Ostrea edulis*, the *O. hippopus*, the *O. mediterranea*, etc., are eaten. Their flesh, easily digested, is principally formed of very assimilable albuminoid substances accompanied by phosphorated fatty matters and glycogen.

Unfortunately oysters change rather quickly when they are kept and are only succulent and without danger at the time when they are not spawning—from October to April. Again, it is necessary that they should not have been fished for at the mouths

of rivers or basins in which drains or cesspools are sometimes discharged. In this case they can become poisonous and transmit the bacilli of typhoid fever.

Here is the percentage composition of the flesh of the oyster, of the comestible mussel, and the heart-shell or cockle (*Cardium edule*):

	Oyster.	Mussel.	Cockle.
Water	80·52	82·20	92·00
Nitrogenous matters	9·04	11·25	4·16
Fatty matters	2·04	1·21	0·29
Non-nitrogenous matters	6·44	4·04	2·32
Mineral salts	1·96	1·30	1·23
	J. Koenig (Average)	Balland	

The flesh of these animals appears to be very rich in a special glycogen, that of the mussel particularly.

Amongst the edible crustacea let us quote the crawfish, shrimps, crayfish, lobster, crab, etc. Their flesh is very phosphorated and very savoury, but rather difficult to digest, and ought only to be consumed seasoned and prepared with spices.

Crustacea, mussels, etc., can provoke nettlerash, eczema, nausea and diarrhoea. Shrimps and certain crabs make delicate and peptogenic dishes.

Finally, the ovaries of sea urchins, the ducts of some actiniae and certain medusae are eaten. These are exciting aliments, rich in phosphorus and organic bromine and iodine.

Here are some analyses of the flesh of these animals:

	Tortoise.[1]	Frog.	Shrimp.	Lobster Flesh.[1]	Crawfish.
Water	77·60	80·13	78·80	76·62	82·30
Nitrogenous matters	16·25	16·0	17·98	19·17	13·59
Fatty matters	1·16	0·10	1·00	1·17	0·57
Extractive matters	2·08	3·46	1·01	1·2	2·89
Mineral matters	2·91[2]	—	1·21	1·82	0·65

The flesh of the lobster, shrimp and frog is rich in nitrogenous matters. The oyster, mussel and cockle, on the contrary, are light aliments, kinds of condiments. According to A. Bourchardat, they are suitable for diabetics.

[1] Analyses of Payen. I have found that on an average, in a lobster, the comestible flesh is just half its weight. The carapace, entrails, etc., form the other half.

[2] 1·86 of soluble albumins and 2·48 of collagenous matters.

XVI

MILK

THE value of milk and its derivatives reaches annually, in France alone, to more than a thousand millions. This expresses the importance which this aliment plays in general alimentation. In London, each inhabitant consumes 40 litres a year, in Paris about 60 litres. Added to bread it constitutes a complete food which is sufficient for man for an indefinite period.

The milk of various domestic mammals is a white opaque liquid, of a slightly creamy consistency, of a sweet and slightly perfumed savour, of an insipid odour, of variable composition and easily changeable.

It is essentially formed of an opalescent plasma in which are held in suspension myriads of buttery globules of diameter varying from $\frac{1}{100}$th to $\frac{1}{1000}$th of a millimetre ; this plasma holding in solution, more or less complete, some albuminoid substances, a special sugar and different salts.

The bodies in suspension in the plasma of the milk are of two kinds : 1st, globules of butter which appear to be formed of a very fine extensible envelope of a proteid nature, enveloping a droplet of body fat ; the milk contains about 1,500,000 of them per cubic millimetre of these ; 2nd, fine granulations of phosphates united to a special nucleinic albuminoid body.

The density of milk varies from 1·027 to 1·032—average 1·030 in a woman. This average density is 1·032 in a cow ; from 1·030 to 1·034 in a she-goat ; from 1·037 to 1·040 in a sheep ; from 1·029 to 1·035 in a she-ass ; 1·030 in a mare.

Pure milk, ordinary cow's milk, freezes at 0·53°C. This characteristic figure of the milk of this animal is an excellent sign of its purity (*J. Winter*). If water is added to milk its freezing point is nearer 0°C.

Left at rest, milk separates itself slowly into two layers : the buttery globules, less dense, rise to the surface and form the cream ; the lower liquid, more aqueous, of a bluer tone, constitutes the *skimmed milk*. The rising of the cream can be

hastened by a temperature of 20° to 30° C. by means of centrifugal machines.

The reaction of fresh milk is neutral to litmus; it is acid to phenolphthalein (*Vaudin*). For cow's milk, this reaction corresponds to about 1·1 grms. of free phosphoric acid per litre; for woman's milk, to 1·20 grms.; for that of a she-ass, to 0·3 grm. of free phosphoric acid per litre. This acid reaction is especially due to the proteid matters of milk.

Milk oxidizes gradually when it is kept. It becomes acid to litmus, even protected from the air, and ends by curdling. This acidity, due to the production of lactic acid by fermentation of the sugar of milk, is hastened by slight heat. The matter which becomes insoluble by coagulation of the milk is casein, the principal albuminous substance of its plasma. Before its coagulation, this casein was not however dissolved, properly speaking, in the milk: it does not pass in fact through porous unglazed porcelain even in vacuo, when one tries to separate from milk its soluble parts by this mode of filtration. It exists in the milk in a distended and mucilaginous condition, forming an opalescent demi-solution whence the mineral and organic acids precipitate it in separating it from the phosphates, and taking possession of the potash and lime to which it is united. It is this case in which, modifying itself under the action of the special ferment of *rennet* (Casease or Lab.) and, transforming itself thus into an entirely insoluble matter caseum, or cheese, thus causing the curdling of the milk.

Submitted to stomachic digestion, the casein of the majority of milks gives a residue of nucleins and para-nucleins. Together with this principal albuminoid, milk contains an albumin and a globulin coagulable by heat, constituting what has been called *lact-albumin* (Filhol; A. Béchamp; Sebelin; Hammarsten; Arthus).

All these albuminous substances together form from 1·5 to 5·5 per cent. of the weight of the milk. Neither proteoses nor peptons are found there.

The caseins of different milks are not identical among themselves. That of human milk does not precipitate by diluted acids. The butter from which the buttery globules are formed contains olein and margarin, with 2 per cent. of butyrin and a slight quantity of stearin and myristin. There are found in commercial butter, interposed with the buttery globules, some particles of casein, a little lactalbumin and lactose dissolved in a small quantity of serum, soluble ferments and microbes being the immediate causes of its souring.

The proportion of butter is essentially variable in milks (10 to 60 grms. per litre in that of a woman, 30 to 82 per cent. in that of a cow).

The *milk-sugar* or lactin which is found dissolved in the plasma of the milk, did not pre-exist in the blood of the animal; it forms only in the breast. This sugar appears to be the same for all mammifers. It is a bihexose corresponding to the formula $C^{12}H^{22}O^{11}$, H^2O when it has been separated from the serum of the milk by crystallization. It constitutes then a white matter, crisp under the teeth, slightly sweet, soluble in six parts of cold water, fermentable, reducing Fehling's solution, but not in the same proportions as glucose. Human milk contains from 25 to 70 grms. of this sugar per litre; that of the cow or mare 35 to 50; that of the ass 50 to 75 grms.

Besides the preceding organic matters, milk contains some lecithins, phosphorized and nitrogenous fat substances of which we shall speak à propos of the egg, and which constitute one of the good forms under which phosphorus is assimilated. Cow's milk contains, on an average, 0·90 grms. to 1·13 grms. per litre, that of a woman 1·70 to 1·83 grms. (*Stoklaza*).

Another very important phosphorized and nitrogenous combination of milk is phosphocarnic acid or *nucleon* (which is precipitated by the ferric salts). Nucleon, under the influence of water, of baryta water at 100°, divides itself into phosphoric acid, carnic or creatic acid $C^{10}H^{15}N^3O^5$ and carbo-hydrate. Out of 100 parts of total phosphorus, cow's milk contains 6 parts, that of a woman 4 parts, in the form of nucleon. This substance appears to be the principal agent of the assimilation of phosphorus, lime and iron in the system.[1] Human milk contains 1·24 grms., goat's milk 1·10 grms., cow's milk 0·57 grms. of nucleon per litre.

We also find in milk some traces of urea, creatin, citric acid, alcohol, colouring and perfumed matters, finally diastasic ferments and microbes. These diastases are found again in a measure in *whey* produced by the coagulation of milk by rennet or by acids. One of these diastases injected under the skin has the property of lowering the temperature of the feverish (*Dr. Blondel*); another, of gradually rendering casein soluble, even when coagulated; another of liquefying and hydrolyzing starch (*A. Béchamp*). Milk contains also dissolved, suspended in its plasma or combined, valuable mineral matters for the development of young subjects: human milk on incineration yields from 1·36 to 6 grms. per litre; that of the cow from 5 to 9 grms.; that of the ass 5 grms.; of the goat 5·6 grms. Here is the analysis of these mineral matters calculated to a litre of milk:

[1] Seigfried, *Bull.*, t. XVI, p. 146; t. XVIII, pp. 912, 913.

	Woman.	Cow.	
Chloride of sodium	1·35	0·81	0·46
„ potassium	0·41	3·41	0·99
Phosphate of lime	3·95	3·87	3·46
„ soda	traces	—	—
„ magnesia	0·27	0·87	0·66
„ iron	traces	traces	0·25
Carbonate of soda	—	—	0·67
Soda (united with albuminoids) . .	—	—	—
Sulphate, silicate of potash . . .	—	—	0·79
Fluoride of calcium	traces	traces	—
Total per litre	5·98	8·96	7·28
	Filhol and Joly		Marchand

According to Bunge, 1,000 parts of milk contain:

	K^2O	Na^2O	CaO	MgO.	Fe^2O^3	P^2O^5	Cl.
Human milk . . .	0·78	0·23	0·33	0·06	0·004	0·47	0·44
Cow's milk . . .	1·77	1·11	1·60	0·21	0·004	1·97	1·70
Mare's milk . . .	1·05	0·14	1·24	0·13	0·020	1·31	0·31

According to Messrs. Friedjung and Jolles, 3·5 to 7 milligrms. per litre of iron is found in human milk. It appears united with the casein.

Finally, by the air pump, we extract from 100 volumes of milk about 3 volumes of gas formed especially of carbonic acid with a little nitrogen and oxygen. They are abundantly set free at the time of the digestion of the milk, or when it is filtered in vacuo through the semi-vitrefied porcelain. The carbonic acid appears to me to be feebly combined in milk, partly with the casein, partly with the phosphates and alkaline carbonates.

A litre of cow's milk furnishes, on an average, 750 Calories; sweetened with 60 grms. of saccharose per litre, it corresponds to about 1,000 Calories. Here are the characteristics of each of the most common milks.

Human Milk.—The best milk for the development of the young is that which comes from women of 21 to 32 years of age, robust, of a calm and cheerful character, fair or dark, of an average stoutness, having a healthy skin, good teeth, and a sustained appetite. Such are the external characters of good wet-nurses.

Human milk is opaline, rather sweet, alkaline to litmus, almost odourless. It does not coagulate even in heat, under the action of diluted acetic acid, but rennet curdles it into light flakes. The casein of this milk is not the same as that of cow's milk; it does not precipitate by chloride of sodium, but by the

addition of sulphate of ammonia in excess. It is a kind of lact-albumin. It differs further from the ordinary casein in that its digestion does not leave nucleinic matters. The lact-albumin of human milk differs also from that of cow's milk by its rotatory power (Béchamp).[1]

It has already been said that human milk is much richer in lecithins, nucleons and directly assimilable phosphorus in organic forms, than any other milk and especially that of the cow.

Here is a table of the composition of human milk :

Composition (per litre) of Human Milk examined under Variable Conditions.

	Composition, General Average.	Rich in Nourishment.	Insufficient Nourishment.	Nourishment rich in Fat.	Nourishment poor in Fat.	Average. English Women.	Average. French Women.
Density	1·030	—	—	—	—	—	1·032
Water	874·1	885·6	901·3	905·6	895·6	877·9	868·2
Casein	10·3	20·9	16·0	7·5	7·2	25·3	24·3
Albumin	12·6					38·7	46·8
Butter	37·8	46·9	28·3	19·5	22·5	56·4	57·4
Lactose	62·1	45·1	52·7	70·7	73·1	—	—
Mineral salts	3·1	1·5	1·7	1·8	1·6	2·5	1·99
Fixed residue	125·9	—	—	—	—	123·5	131·8
Authors	J. Koenig	Pfeiffer		C. Krauch		Forster	Vernois & Becquerel, Doyère, etc.

According to Lebedeff, the butter furnished by this milk is formed half of olein, half of palmitin and myristin, with a little stearin and traces of butyrin. The principal fats are accompanied by lecithins. The butter of this milk melts at 30°.

A woman who suckles, secretes from the third to the sixth month, from 1,000 to 1,300 cub. cent. of milk per day. A nourishment abundant in albuminoids increases especially the quantities of butter and sugar ; an excess of alimentary fats impoverishes the milk in butter rather than increases it. An insufficient diet diminishes the casein and butter but not the sugar. The poverty of foods in albuminoids lowers the quantity of milk secreted and its richness in butter.

Anaemic, cachetic, feverish or hysterical women have milk poor in casein and fats, and less plentiful. Suckling is neither good for them nor for their infants. It is well to avoid also the

[1] The same author considers human milk sugar different to that of cow's milk. He distinguishes it by its mode of crystallization and its sweeter flavour. This remark deserves confirmation.

milk of nurses who have undergone very violent emotion, fits of anger or prolonged grief.

Cabbages, crucifers, garlic, onions, labiated plants, communicate their flavour and their odour to the milk. The addition of phosphate of soda to food increases the proportion of soluble phosphates in the serum of the milk.

Repose of the nurse enriches her milk in butter.

In a woman, the composition of the milk is scarcely modified from twenty to thirty-two years of age. After that age it contains less mineral matter. The return of the periods diminishes a little the lacteal secretion, but the milk is generally altered only at the menstrual periods; they cause it to be slightly purgative.

In the course of sharp illnesses, the lacteal secretion diminishes; but for an equal quantity of milk, the casein and the salts increase. It is wise to avoid giving an infant the milk of a nurse suffering from tuberculosis. The milk of a syphilitic should also be prohibited.

Woman eliminates by the milk a part of the normal or accidental principles of her sanguineous plasma; if this is rich in phosphates, for example, or in lecithins, the milk will be remarkably phosphorated or lecithinized. If the nurse drinks alcohol she will pass it by means of her milk to her nurseling, as has been well established by M. Nicloux. Opium, quinine, iodide and bromide of potassium, chloral, ether, Glauber's salts taken by the nurse, are also found again in the milk. Mercury, arsenic, salicylate of soda, antipyrin also pass into it but with greater difficulty. Many of the odoriferous or colouring matters of foods are partially eliminated with the milk. It is evident that the toxins and ptomaines of the sanguineous plasma of the mother, when she is ill, must be partially submitted to the child by the milk.

The researches of Honigmarun prove that frequently human milk contains *staphylococcus albus* and *staphylococcus aureus*. Escherich admits also that, in some cases, as septicemia for example, the pathogenic microbes of the mother may pass into the milk.

Cow's Milk.—This milk is white or yellowish white. Its casein precipitates easily at a temperature of 40° or 50° by dilute acetic acid.

Water absorbed in drinking, salt, the meadow pasturage, etc., make the milk secreted by the cow much more abundant but a little more aqueous. Pollards, bran, sweetened roots, leguminous plants, oilcake, render it more abundant and more buttery. The leaf of the chestnut, barley straw, communicates some bitterness to it.

In the various successive parts of the same milking, the butter

steadily increases as well as the casein. Fatigue diminishes the butter in cow's milk.

Clover, hays rich in labiated plants, aniseed, etc., give the milk agreeable tastes and perfume. Absinth, genista, shoots of the elder, artichoke, rape-seed, malt, oilcake [1] and sprouting potatoes communicate disagreeable and sometimes bitter flavours to it. The leaves of the oak render it astringent; colchicum and euphorbia make it a dangerous drink. Carrot, saffron, indigo, mercuriales and madder communicate to it their *colouring properties.* These last milks exposed to the air become reddish, yellow, bluish, etc.

If the cow is castrated during lactation, the butter of its milk increases by about a quarter.

Here is a table, relative to a litre indicating the variations of composition of this valuable milk:

COMPOSITION OF COW'S MILK.

	Healthy Women of the Neighbourhood of Paris.	Average (German).	Meadow-fed Cow milked after Exercise.	Same Cow Resting in Stable.	Milk of 200 Days.	The Same Milk—310 Days.
Density .	1·032	1·033	1·034	1·031	—	—
Water . .	864·3	857·7	865·0	857·0	877·0	868·0
Albuminoids	33·3	54·0	54·0	49·0	30·0	34·0
Sugar . .	52·8	40·4	38·0	38·0	47·0	60·0
Butter . .	42·0	43·0	37·0	51·0	45·0	36·0
Mineral salts	7·6	5·4	6·0	5·0	1·0	2·0
Dry residue	135·7	142·9	135·0	143·0	123·0	132·0
	Adam	Gorup-Bésanez	Lyon Playfair		Boussingault and Le Bel	

Goat's and Sheep's Milk.—Goat's milk is more creamy and more fragrant than that of the cow, which it resembles; it curdles by rennet. Sheep's milk is rich in butter and casein and very nourishing.

[1] The malts are the parts of germinated barley, exhausted of their soluble principles. This same name is also applied to the residue of the expressed pulp of beetroot. Dreches, after they have begun to ferment, are often given to cattle. They make the milk watery and give it an unpleasant taste. *Oilcakes* are the residue of the oilpress; they result from the expression while hot of the grain of colza, flax, sesame, field poppies, etc. This highly nitrogenous residue also contains fatty matter. These industrial foods modify the qualities of the milk. They often become more nitrogenous, more fatty, but mediocre and less agreeable. The oil-cake of sesame makes the butter too soft; that of colza possesses a very disagreeable flavour; the oil cake of field poppies diminishes the richness of the milk and gives it a special flavour.

The following figures give the percentage composition of these two milks :

	Goat's Milk.	Sheep's Milk. (Average).[1]	Sheep's Milk. (Average).[2]
Water	869·5 grms.	799·7 grms.	814·4 grms.
Albuminoids	44·3 „	61·8 „	51·2 „
Sugar	48·5 „	53·7 „	52·6 „
Butter	60·7 „	74·0 „	71·8 „
Mineral salts	9·1 „	10·2 „	10·2 „
Acidity	—	3·7 „	3·8 „
Dry residue per litre . .	164·3 grms. (Ferry)	200·3 grms. (Tillat)	185·6 grms.

Ass's Milk : *Mare's Milk.*—Ass's and mare's milk singularly resemble human milk in their composition and the nature of their casein. That of the ass is a little poorer than human milk in butter and sugar ; it is sometimes a little richer and sometimes a little less rich in casein. The latter, like the casein of human milk, entirely digests without leaving any residue of nuclein. This milk is very changeable ; if it is kept after milking, it should be kept in a cool place and only warmed at the moment of drinking and in a water bath without sensibly exceeding 38°. For invalids, mare's milk can be used as a substitute for ass's milk. It has a preferable flavour and is still more easily digested. Here is the analysis of the two milks. They are calculated per litre :

	Ass's Milk. (average).	Mare's Milk.
Density	1·032	1·031
Water	914·0	890
Casein and albumin	12·3	27
Butter	31·0	25
Sugar	69·3	55
Extractive matters and salts	4·5	5
Dry residue in 1,000 parts	1,031 grms.	1,002 grms.

CHANGES—ADULTERATIONS OF MILK.

The milk of a cow which has calved a few days previously, presents some intermediary characteristics between those of colostrum and of perfect milk. Microscopic examination shows large white globules like raspberries, endowed with amyboid movements. The globules disappear towards the end of the second week. The milk is then saleable ; but it is not until the second month that it acquires all its qualities of sweetness, perfume and oiliness.

[1] Animal fed on granite soil. [2] Animal fed on chalky soil.

Milk, we have said, should be neutral to litmus paper. If it has been kept some time it may become acid and even curdle or "turn" when heated. This is sometimes remedied by adding a little carbonate of soda or lime water.

By culture in gelatin or in some sweetened broth, it is possible to develop typical ferments which milk contains and which tend to alter it and even sometimes render it dangerous. The most remarkable of these microbes are: the *lactic ferment*, motionless, aerobe from 1 to 2 μ. long, which coagulates the milk and forms lactic acid at the expense of the milk-sugar; the *thyrothrix tenuis* which curdles, then rapidly liquefies the casein; it is aerobic; the *T. filiformis* which also peptonizes it, but less actively, after the manner of trypsin; the *T. distortus* and *geniculatus* which transform the milk into a doubtful liquid containing acetate and valerianate of ammonia as well as leucin; the *T. turpidus*, an aerobic ferment like the preceding, which liquefies the casein after having coagulated it, and produces ammonia, butyric acid, leucin and tyrosin; the *T. urocephalum*, in operation aerobic but which, sheltered from air, liquefies the casein with the production of carbonic acid and free hydrogen. In contact with it, milk acquires a putrid odour. The *T. claviformis*, purely anaerobic; it determines the coagulation, then the fluidification of the milk of which it attacks the casein and sugar with formation of peptons, alcohol, fatty acids, carbonic acid and hydrogen; the *T. catenula* which modifies the milk whilst precipitating the casein and digesting its dissolved albumins which it changes into peptons, liberating carbonic acid, hydrogen, and a little sulphuretted hydrogen; lastly, the *Bacillus butyricus* which is killed by oxygen, but which, sheltered from the air transforms the milk-sugar into butyric acid with liberation of CO^2 and H^2 and dissolution of the casein.[1]

FIG. 5—MILK FERMENTS.—1. Tyrothrix distortus; 2. T. virgula; 3. T. urocephalum; 4. T. claviformis.

We may find accidentally in milk white and golden staphylococcus bacilli, *subtilis* and several other microbes of the fæces.

[1] One has pointed out also in milk the *Bacillus mesentericus vulgatus, the clostrydium butyricum,* some *saccharomyces*, etc.; lastly, that which is more serious, the microbes of typhoid fever, tuberculosis, diphtheria and scarlatina.

The greater part of these micro-organisms, recognizable under the microscope after or before culture, are the agents of the spontaneous changes in milk and of the ripening of cheese.

The milk of tuberculous cows presents under the microscope agglutinated globules, like mucus. The leucocytes are distinguishable by their insolubility in ether, their disappearance under the influence of very diluted soda, their two or three nuclei which diluted acetic acid renders more apparent.

Sterilization of milk with which we shall occupy ourselves farther on is not assured by simply boiling for a few moments ; certain spores can resist for several minutes 98° to 100°. But boiling also destroys the soluble ferments of the milk, alters its taste a little and even its composition, a part of the casein separating itself through insolubility in the state of floating membranules. Milk modifies itself then at 100°, and here is what would be, according to M. Ch. Girard, the composition of the same milk before and after being boiled :

	Before.	After.
Water	882·7	864·5
Butter	38·1	44·7
Lactin	49	50
Casein and albumin	44·6	34·2

We perceive that the apparent alteration affects above all the casein which partly disappears, without doubt, through becoming insoluble.

Boiled milk, if it is more healthy, is therefore less nutritive and less assimilable than the raw. We shall speak farther on of *sterilized milk*. The changes which milk can be voluntarily submitted to are numerous. The principal one is skimming ; it consists in taking from the milk, either by spontaneous separation, or by centrifugal action, the most buttery part and also the most savoury. Here is, according to M. Duclaux and M. P. Lemaire, what would be the

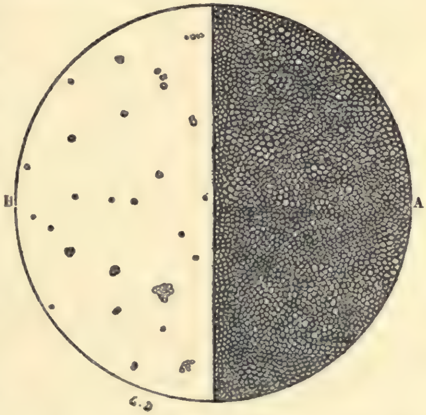


FIG. 6—A. NORMAL MILK BEFORE SKIMMING : B. AFTER SKIMMING and the addition of 20 per cent. of water mixed with a little bicarbonate of soda.

composition of pure milk, of skimmed milk and of cream, this last deducted in the proportion of 8 to 9 parts for every 100 parts of milk:

COMPARATIVE COMPOSITION OF PURE AND SKIMMED MILK.

	Normal Milk.	The Same Skimmed.	Cream of this Skimmed Milk	Normal Milk.	The Same Skimmed after 12 hours.	The Same Skimmed after 36 hours.
Water . . .	87·25	89·70	58·63	87·0	89·8	90·0
Dry extract .	—	—	—	12·9	10·2	10·0
Buttery matters	3·50	0·77	35·00	4·35	1·35	0·93
Casein . . .	3·90	4·02	2·75	2·7	2·92	3·07
Milk-sugar . .	4·60	4·74	3·12	4·98	5·05	5·06
Mineral matters	0·75	0·77	0·50	0·79	0·77	0·80
P^2O^3 . . .	—	—	—	0·105	0·12	0·12
	100·00	100·00	100·00	100·00	100·00	100·00
		Duclaux			Lemaire	

We see the advantage of skimmed milk in some cases, in the obese for example, also in the case of all those who, needing a milk diet, either digest badly or do not require an excess of fatty bodies. Milk from which the butter has been removed by churning constitutes a very nourishing and easily digested drink. It is more easily kept than pure milk.

Another adulteration of milk consists in the addition of water. We have observed before how it is possible to detect this adulteration by determining the freezing point, which should be normally 0·53° C. for pure milk. The density of the milk is also a practical and rapid means of check. The density of cow's milk ought not to be lower than 1·029° at the temperature of 15° C.

Skimming and watering are the two principal adulterations of milk. The second is graver than the first, water added to milk bringing with it its living organisms, often injurious and rendering it at the least easily putrescible.

PRESERVATION OF MILK.

Milk left to itself rapidly becomes the prey of its ferments, and of the microbes of the air. It changes, becomes sour, coagulates and putrefies. It can besides carry with it the germs of various maladies: diphtheria, scarlatina, typhus of horned beasts, typhoid fever, etc. It was tried then to be preserved unchanged.

The oldest method consists in boiling it; the operation can be repeated if necessary. But heat changes the milk each time and does not always confer upon it a long immunity. It is preferable to preserve it by concentrating it. For this, the milk is evaporated in vacuo, mixed or not with a certain quantity of

sugar, to a thick consistency, then poured into metallic bottles which are soldered and afterwards heated in a digester. This *condensed milk* can be kept almost indefinitely.[1]

According to J. Koenig, condensed milk corresponds to the composition :

Condensed Milk.	With the addition of Sugar.	Without Sugar.[2]
Water	25·61	58·99
Albuminoids . . .	11·79	11·92
Butter	10·35	12·42
Lactose	13·84	14·49
Saccharose (added) .	36·22	0·00
Ash	2·19	2·18

Often milk is sterilized without evident concentration. Immediately after milking, it is filtered and *pasteurized*, that is to say, heated to 70° or 75°, then quickly cooled ; we thus confer upon it the power of resisting for several days spontaneous changes. Sometimes it is heated up to 70° with pressure of carbonic acid. But even in this case pasteurization does not destroy all the germs, particularly that of tuberculosis, the peptonizing bacteria of cowdung, and of the dust of houses and streets, etc. To obtain a complete sterilization allowing of the preservation of milk for several weeks, it is necessary to fill glass or metal jars with it. These are then heated for some minutes to 106° to 110° or better for one hour to 98° to 100°. If necessary the operation may be repeated.

Milk sterilized at 102° still contains living spores, in particular those of cowdung, which they subsequently develop ; also sterilized milks can, after a time, become dangerous. Infantile scurvy or Barlow's disease, frequently noticed in the case of young infants nourished on sterilized milk, is due rather to the harmful qualities caused by its being kept too long, or by toxins which prevent it from being easily assimilated, than to the destruction of its ferments and above all to the pretended precipitation of a little citrate of lime.[3]

If it is necessary for sterilized milks to acquire an almost indefinite resistance to subsequent changes ; if they have to be

[1] Another condensed milk, sterile and not sugared, is also manufactured. It contains 37 per cent. of dry substances, of which 10 per cent. are of proteid matter, 10 of butter and 12 of milk-sugar. Germany also makes peptonized milks with the addition of maltose, dextrin, albumin, albuminates, hypophosphites, phosphates, etc. These milks, condensed in vacuo, *without sugar*, after the addition of boiling water, etc., can be used to nourish infants in place of sterilized cow's milk.

[2] P. Cazeneuve, *Sterilization of Milk*, Lyons, 1895.

[3] The citrate of lime only becomes partially insoluble to heat, and it is too insufficient in milk for its partial precipitation to have any importance.

sent far off into tropical countries, they are heated again up to 110° two or three times in the digester at intervals of some days. Unfortunately, heating milk above 80° alters it somewhat seriously; on the one hand it destroys the action of its natural zymases;[1] on the other it seriously modifies the process of emulsion of the fats which, after this operation, tend to reunite themselves into clots and to float on the surface. Further, the casein of overheated milk is less assimilable, the lactoalbumins and lactoglobulins are coagulated; finally, the milk-sugar becoming converted into caramel and sensibly acidified by the heat, communicates to the milk, cooked above 100°, a yellowish colour and a special taste. Sometimes if it is well sterilized, even to 106 to 112°, it is perfectly digestible by young children. M. Marfan rightly insists on the necessity of doing this sterilization, in the summer especially, immediately after the milking. It is not necessary indeed to leave the microbes of the milk sufficient time to secrete their toxins and other products of change which, once formed, would continue in the liquid, even after the action of heat.

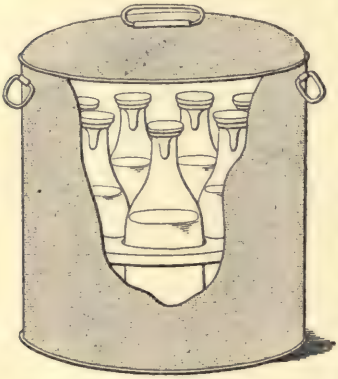


FIG. 7. SOXHLET'S APPARATUS FOR STERILIZING MILK AT HOME.

Sterilization of milk can be done practically at home, thanks to the very simple apparatus of Soxhlet, Budin, etc.

The milk is poured into glass bottles with large necks of 80 to 120 cc. which it nearly fills (Fig. 7). These bottles are covered by an indiarubber hood attached to the thick brim of the vessels. These are placed in a metal basket which is plunged into a water bath with a cover in which the water rises a little above the level of the milk contained in the bottles. To obtain a sufficient sterilization, this water is kept boiling during 45 to 50 minutes. This operation can be repeated three days after, if necessary, on the same bottles. By cooling the steam, a vacuum is produced, and the india-rubber cover adhering closely to the neck of the bottle and incurving, as seen in Fig. 7, prevents all re-entrance of air and microbes.

[1] It is by the destruction of its *oxydase* that we can recognize that milk has been cooked or heated above 80°. To make an experiment characteristic of the cooking of milk, to 10 cc. of this liquid we add 1 to 2 drops of weak oxygenated water, and 2 to 3 drops of a solution of 2 per cent. of chlorhydrate of paraphenylendiamin. If the milk has not been warmed above 80°, it produces a greyish blue tint which soon turns to indigo blue. The milk remains white if it has been boiled.

These sterilized milks, produced in the manufactory or at home, render great service. They can, when really necessary, be substituted for maternal milk. They allow young children to combat with persistent diarrhoea and dysentery. Certain invalids who are unable to take ordinary milk, tolerate sterilized milk very well. It is accused, and this is a disadvantage in some cases, of constipating infants or invalids. It has been supposed that these milks provoke sometimes a sort of scurvy which had disappeared by substituting ass's milk or by the use of coffee or lemon.[1] The statistics collected concerning these affirmations have not been well substantiated.

In any case M. Budin does not consider it prudent to give sterilized milk to an infant during the first months.

The great advantage of sterilizing milk by heat is that it causes its soluble ferments to disappear and especially its oxydases. It has been proposed to obtain this sterilization by the addition of chemical agents such as borax, salicylic acid, formol, oxygenized water, etc. Several objections must be raised to all these methods. The most general is that we cannot prove that the continuous use of these milks is without disadvantages, or that their assimilation is as easily produced as that of ordinary milks. The contrary has even been observed. Forster and Schlenker[2] have established that boracic acid diminishes the degree of absorbability of the albumin, stimulates the mucous hypersecretion of the intestine and exaggerates the elimination of phosphoric acid. Salicylic acid has the same disadvantages, even at 0·50 grms. per litre, a sufficient quantity to prevent the putrefaction of the milk. Behring, in his turn, has for some years proposed adding $\frac{1}{10000}$th of formol to fresh milk. He writes that young calves nourished with this milk thrive very well. But Trillat has made experiments which establish that formolized milk—even slightly so—digests badly or not at all.

Another objection to these practices is that they do not kill the microbes, still less their spores, which are, as it were, asleep but which may be awakened in the intestine.

Modified Milks.—Attempts have been made to give infants not only a milk exempt from microbes and toxins, but one approaching as nearly as possible in its composition, maternal milk. Hence these strange denominations of milks *feminized* or *maternisized*. They are generally obtained from cow's milk.

Let us first remark the difference of composition in the average cow's milk and human milk. Calculated per litre, we have :

[1] *Gaz. méd. des hôpitaux*, t. IX, 1903.

[2] "Über die Verwenbarkeit der Borsaure," etc., Forster, *Arch. Hygiène*, t. II, p. 75. Milks sterilized by borax, salicylic acid, etc., are not inoffensive.

	Human Milk.	Cow's Milk.
Water	868	857·7
Casein and albumin . .	24·8	34·0
Butter	42·8	40·4
Lactose	56·9	43·0
Mineral salts	2·0	5·4

Human milk is therefore poorer in casein and mineral salts and richer in sugar, than cow's milk. By an appropriate diet, one can obtain cow's milk nearly corresponding to the above average composition, but enriched in fatty bodies containing even 55 to 60 grms. of butter per litre. These fatty milks, with the addition of half of their volume of a solution in water of 56 grms. of lactose or of saccharose per litre, then correspond with the following composition per litre of the mixture :

Water	858 grms.
Casein and albumin	23 „
Butter	39 „
Lactose	52 „
Mineral salts	3·6 „

a composition which is singularly like that of human milk (Gaertner). Richt has proposed diluting cow's milk with boiled water (its volume or half volume) and then adding about 15 grms. per litre of the albumose of egg.

Thus modified, these milks are only, it is true, a rude imitation of the milk of our species. They differ very sensibly by the nature of their casein and of their sugar (if cane sugar is used). But, well sterilized, they appear nevertheless to have rendered some real service.

Various other preparations destined to replace human milk have been extolled : albuminous milks, milks with the addition of cream and whey, etc. Flours or dry powder, mixtures of milks and flour called *milk foods* have been made : they approach more or less nearly to the composition of milk, and experience has shown that they are readily accepted by the stomach of the young child, at least from the sixth or eighth month, and that they can assist the nurse, and little by little be substituted for her. The best known of these preparations is obtained by adding to concentrated cow's milk some ordinary sugar and a powder which is prepared with paste of wheat, manufactured without salt or yeast, carefully cooked in the oven until it is transformed into dry and crisp flakes where the starch has been changed in a great measure into dextrin. This biscuit reduced in the mill into very fine powder, is afterwards perfectly mixed with concentrated milk and the whole is dried, pulverized, sterilized and preserved in boxes protected from the germs of the air. This is a good preparation which allows weaning to take place without too great abruptness for the child or fatigue for the nurse, and which can sometimes be given to invalids.

XVII

DERIVATIVES OF MILK—CREAM OF MILK—WHEY—FERMENTED MILK—PREPARATIONS OF CASEIN—CHEESE

MILK furnishes to alimentation a great number of derivatives: butter, cream, whey, fermented milks (koumiss and kephir), the alimentary powders and solutions of casein, cheese and the milk sugar. We are going to examine the derivatives, leaving aside for the moment the chief of them—butter—which we propose studying with the fatty bodies in one of the following chapters.

Cream of Milk.—Cream separates, owing to its lesser density, from milk left at rest or centrifugalized. It rises slowly to the surface of milk left by itself. It is collected by skimming. Churning easily transforms it into butter, but the butter is not solely composed of cream. Cream contains besides fat bodies, casein, a few lecithoproteids, lactalbumin, and a good portion of matters which remain in suspension in the primitive milk (microbes, ferments, phosphatic and other granulations) drawn along by the rising of the butter. The composition of cream is very variable; here are two extreme analyses of it:

Water	617	733
Butter	320	180
Casein	27	40
Lactose	31	40
Ash	5	7
	1,000	1,000

We see that cream is an aliment very rich in butter and very poor in casein. It is very difficult to digest if consumed in large quantities, it is unhealthy if the original milk has not been properly collected or if it comes from unhealthy cows. Cream is very changeable by reason of the microbes of the milk which it collects and which abound in it, and are reproduced owing to a sweet serum rich in phosphates, which it contains interposed between its fatty globules. Also, in summer especially, the cream spoken of as "whipped," has often been the cause of serious complaints.

The *milk* from which the cream has separated and risen natur-

ally to the surface, is called *skimmed milk*. It contains about a fifth of the fatty matters of the original natural milk, but almost the whole of the other substances is found there.

Whey.—The term *whey* is often applied either to a clear or opalescent liquid which remains when milk is coagulated by spontaneously turning sour, or to that which results from the caseification of milk by rennet. This causes confusion and it is desirable to distinguish between these two liquids. The whey from caseification, the true *whey*, contains a proteose resulting from the division of the caseogen by the casease. This proteose does not exist in whey from acidification. In both liquids we find also the lactalbumins and lactoglobulins of the original milk (about 1 per cent. of the liquid), also some very small quantities of other organic matters (urea, alcohol, lactic acid, derivatives of lecithins, very active oxidizing and hydrolyzing ferments, etc.). Finally, whey contains the whole of the sugar and mineral salts of milk, with the exception, however, of the earthy phosphates, the greater part of which is carried away by the cream, or is left in the coagulated casein.

The composition of whey, per litre, is as follows :

	W. Fleischmann. (Cow's Milk).	Lehmann. (Goat's Milk).
Water	933·0 grms.	937·70 grms.
Albuminoids	10·5 ,,	5·80 ,,
Fats	1 ,,	0·20 ,,
Milk-sugar	44 ,,	49·70 ,,
Lactic acid, etc.	3·3 ,,	—
Mineral matters	8·2 ,,	6·60 ,,

It is a liquid slightly nutritive by its albuminoids, its lactose and its phosphates ; diuretic and a little laxative by its sugar and salts. It is particularly useful when it is important to free the system from its nitrogenous residue more or less toxic : affections of the liver, stubborn constipation, infectious diseases, etc. The "whey cure," formerly very much in vogue, is practically abandoned now, perhaps because of the difficulty there was of being certain that the milk serum came only from healthy and well-kept cows. It is, however, necessary to remark that the infectious agents which may be found in the milk which furnishes whey, are in a very great measure, if not entirely, carried off at the moment of coagulation and remain in the curd.

Butter-milk.—This name is given to a liquid left by the churning of the cream of milk or of milk itself when the butter has been extracted from it. It has, in these two cases, very nearly the same composition. It is as follows, according to Lam, compared with that of the corresponding milk and calculated for 100 parts ;

	Cow's Milk.	Butter-milk.
Dry residue (average). .	11·8–13·7 grms.	8·7–9·8 grms.
Butter	2·8– 1·7 ,,	0·5–0·9 ,,
Casein and lactalbumin .	5·4 ,,	2·5–2·7 ,,
Lactine or milk-sugar .	4·04 ,,	3·0–3·5 ,,

Butter-milk is far poorer in fat than milk. It also appears poorer in casein, which is probably partly coagulated owing to the acidification of its centre and is carried away with the cream. Thus butter-milk is far from possessing the composition of skimmed milk. It is most often acidified by the lactic acid of fermentation. It is recommended, mixed or otherwise, with cereal decoctions, for the alimentation of athrepsic children. It is generally used sterilized and sweetened. We shall revert to this subject (G. Jacobson, "Alimentation of Infants," *Arch. de méd. des enfants*, February, 1903. See also Teixeira de Mattos, *Jahrb. f. Kinderheilk.*, January 1902).

Koumiss; Kephir; Yaourt

Koumiss.—This name is given to the product of lacto-alcoholic fermentation of mare's milk. Koumiss had long been used only in the steppes of Southern Russia and Tartary. But for some years it has also been made in Northern Russia and even in Germany for the needs of invalids. The Tartars for making koumiss, mix 10 volumes of fresh and tepid mare's milk with 1 volume of previously prepared koumiss and which contributes its own special ferment. This mixture is put into an upright cask which is placed in the fresh air, in summer, and not far from a stove in winter. From time to time the mixture is stirred with a stick. At the end of two or three hours, bubbles of gas begin to appear; a rather intense lactic fermentation, afterwards alcoholic, originates in the mass; the liquid acidifies and becomes alcoholic. If it has to be kept for some time, it is advisable, at the end of the first five or six hours of fermentation, to put it in strong and wired bottles which are kept in the fresh air. After some days, a foaming emulsioned liquid is obtained, of a taste at once acid and sweet, slightly recalling almond milk, stimulating the appetite, facilitating digestion and very slightly intoxicant.

In new koumiss, the casein in very thin flakes becomes half dissolved if water is added to it. Later on this casein dissolves either under the action of lactic acid or by partial peptonization. As a matter of fact one finds in koumiss from 4 to 10 grms. of pepton per litre.

Casein thus rendered soluble must not be confounded with lactalbumin.

Here are some analyses of koumiss due to Wieth, and in comparison with them, the composition of the mare's milk which has been used to make it:

	Primitive Mare's Milk.	Koumiss per litre.		
		Of 1 day.	Of 8 days.	Of 21 days.
Water	901·6	918·7	923·8	924·2
Alcohol	0·0	31·9	32·6	32·9
Fats	10·9	11·7	11·4	12·0
Casein	18·9	8·0	8·5	7·9
Albumins		1·5	3·0	3·2
Peptones		10·4	5·9	7·6
Sugar	66·5	3·9	0·9	0·0
Lactic acid	—	9·6	10·3	10·0
Soluble salts	0·8	1·0	1·2	1·2
Insoluble salts	2·3	2·3	2·2	2·3

Koumiss contains alcohol in the same degree as small beer. Its peptones, casein and its easily assimilated fats, considering their origin and extreme division, make of it a liquid at once nutritive, aperient and exciting. Some zymases are found in it analogous to those in the juice of fresh meat.

Unfortunately we cannot easily procure good koumiss in France.

Kephir.—An alcoholic and sparkling preparation very similar to koumiss is made by the inhabitants of the Caucasian mountains and the Tartars, with the milk of their cows and sheep. The fermentation of this milk is provoked, in this case, by a specific agent which bears the name of kephir and has been handed down from Mahomet, who was its protagonist. This ferment is sold in the form of irregular pellets of the size of a millet seed, welded together, granular and whitish yellow. Under the microscope two small organisms are discovered: the one is a special alcoholic yeast, the *Saccharomyces mycoderma*; the other is a bacterium, the *Dispora caucasica,* which appears to play the part of partially peptonizing the casein.

To prepare this liquid the inhabitants of the Caucasus pour the milk of their cows and sheep into leathern bottles, add the kephir powder diluted with a little lukewarm water and leave it at a moderate temperature, stirring it from time to time. After one or two days the preparation is consumed or put into bottles. On the residue remaining in the bottle they pour some fresh milk, and so on.

Kephir very much resembles koumiss; like the latter it is acidulated by lactic acid, but it is less alcoholic and less well peptonized. The following are the analyses, according to Hammarsten, relating to one litre of kephir two days old:

Water	882·6	890·9
Alcohol	7·0	6·8
Lactic acid	8·1	6·0
Sugar	27·8	29·0
Fat bodies	53·5	31·0
Casein	29·8	27·4
Lactalbumin	2·8	1·7
Peptones	0·5	0·7
Salts	7·9	6·5

Thus, in kephir, a small part of the lactose of milk has been transformed into alcohol and carbonic acid, another part into lactic acid. A small portion of the casein has been peptonized. Moreover, the agents of this fermentation of milk have poured their diastases into the liquid.

Kephir can change, become sour and stringy, etc.

There are several kinds of kephir, according to the method and time of fermentation.

Kephir has been prescribed in cases of apepsia, vomitings of pregnancy, tuberculosis and chronic enteritis. It is an excitant of the stomach and an agent of assimilation. It increases the amount of excreted urea, and diminishes the uric acid and urinary acidity. It is, like koumiss, contra-indicated in cases of hemorrhage, plethora, and in renal, vesical and cardiac affections.

Yaourt.—This is a preparation of curdled milk which is obtained in the East by boiling the milk of cows, sheep, or goats on an open fire, concentrating it to about one-third and pouring it into bowls placed in a very hot place where under a large surface the milk still loses water and forms a skin. It is left to cool to 38 or 40° and then a little of the yaourt of the previous day is poured, or rather injected under the skin which has formed without breaking it. Four to five hours later a creamy curd is obtained which becomes solid and can be turned over without running out.

It is an acidulated aliment, very substantial and easily digested once one has become used to it. It can be kept for four or five days, but it quickly becomes sour. It is diuretic and antidysenteric. When care has been taken to remove its upper and most creamy part, it is easier still to digest. In the East it is mixed with a number of other foods. It can be differently flavoured, sugared or salted.

Alimentary Derivatives of Casein.

Everything pointed to the fact that the principal albuminoid of milk—casein—which remains when butter is prepared, would attract the attention of hygienists and clinicians and become the foremost material of industrial preparations destined for the food of invalids, children, weak people, etc. Indeed, this casein, which has the composition of muscular tissue, scarcely produces

during digestion either residues or toxins. It has been applied in therapeutics, especially at the instance of Salkowski, Berlin.

He at first advised a soluble preparation, *eucasin*, obtained in separating by acids the casein of skimmed and centrifugalized milk, and redissolving it in the feeblest possible proportion of diluted ammonia. This substance and numerous analogous preparations (*tropon*, *sanatogen*, *plasmon*, *nutrase*, etc.) all containing, like casein from which they are principally formed, more or less nucleins, phosphates and different salts, seem to have very nearly the same alimentary value and to fulfil the same indications. The following are some summary analyses :—

	Tropon.	Plasmon.	Nutrase.	Eucasin.
Albuminoid matters	90	77·3	85	80
Milk-sugar	—	2·8	—	—
Fats	—	1·3	1	2
Extractive matters	—	1·1	—	—
Water	9	11·3	14	20
Mineral salts	1	6·2		

Another preparation of the same origin, *eulactol*, contains not only the albuminoids of milk but its sugar and fats. It is a sort of condensed skim milk (albuminoids, 28 per cent. ; fats, 44 per cent. ; lactose, etc., 46 per cent.).

All these nutritive substances being nearly without taste can easily be consumed, either alone or mixed with other aliments. But it is necessary that they should be freshly prepared as often as possible ; the small amount of butter they contain will end by turning them rancid in oxidizing in the air. Fresh, they have the advantage of introducing into the system very few indigestible residues, and, what is important, few materials suitable for transformation into extractive biliary or urinary matters. From this last point of view, especially, the preparations of casein have a real dietetic interest. One must not forget, however, that casein in its different forms of non-fermented cheese (white cheese, Neufchatel cheese, cream cheese, etc., of which we are now going to speak) can replace them and sometimes with advantage.

Cheese.

Cheese comes from the curdling of milk, more or less skimmed. It is formed essentially by its casein which, passing to the insoluble state under the influence of rennet, draws along with it, while coagulating, a part of the fatty bodies, of the lecithoproteids and salts. The curdling of milk is obtained by means of the rennet of the young calf, or by an infusion in fresh warm water of the dried-up testicles of this animal.

The distinction between the different kinds or groups of cheeses is of great importance to the hygienist and physician.

They ought to be divided into cooked cheese and fresh cheese. In their turn, they may be fermented, salted or non-salted, thin or fat. These latter come from non-skimmed milks.

Cooked cheese always keeps for a long time. It is obtained generally with the milk of the cow. The principal are those of Gruyère or Emmenthaler, of Parmesan and of Bresse. The curd fat or semi-fat, coming from the action of rennet on milk more or less skimmed, is cooked first, then submitted to a good pressure which clears away the interposed serum, finally, put into loaves which are covered on the surface with salt and which are left for a long time in cellars where the cheese ripens. Their paste always remains acidulated.

Cooked and non-fermented cheeses render great service in the alimentation of invalids. They afford variety in their régime and possess nearly all the advantages of milk, whilst often proving easier of digestion.

Raw cheeses with *strongly salted paste* are those of *Holland*, *Cantal* and *Chester*, made with cows' milk ; and the cheese of *Roquefort* and *Sassenage* made with sheeps' milk mixed with that of the she-goat. *Dutch* cheese is obtained from non-skimmed cows' milk ; the curdle of this milk coloured with arnotto, pressed and coated with salt, is drained as much as possible of its brine, then it is compressed in the form of round loaves and kept in an aerated drying room where it *ripens*, that is to say where it undergoes the slow action of its natural diastases. It is then rubbed with *litmus in bags* which gives it its pretty red colour.

Fresh *Cantal* contains, two days after it is made, 20 per cent. of casein and 4·1 per cent. of albumin. When it is ripe, not more than 12 to 13 per cent. of casein is found ; on the other hand, 7 to 10 per cent. of its albuminous matters have been peptonized by the ferment of the original milk.

Roquefort cheese is made from a mixture of the very fat milk of the sheep and she-goat. Salts and specially suitable ferments are introduced into its curds, particularly a mould, the *Penicilium glaucum* which is cultivated on crumb of bread and which in developing forms in this cheese its greenish belts. During the ripening, the air is made to penetrate into the interior of the mass by piercing it through and through at different points with the aid of knitting needles. Finally, the mass completes its ripening in subterranean cellars in which the temperature is maintained all the year round below 9° or 10°.

The principal cooked *non-salted* cheeses are those of *Brie*, *Coulommiers*, *Gérardmer*, *Normandy*, *Brittany*, *Pont-Lévêque*, *Camembert*, *Livarot*, *Mont-Dore*, etc. This last is prepared with she-goat's milk. *Brie* cheese is made from cow's milk that has been

submitted to rennet at 35° ; the curd which result from it first pressed in the hand, is placed in a kind of basket, large and shallow, where it is pressed and drained with care. It is then rubbed with salt and kept for several days. Finally, it is heaped up in casks in a fresh and dry place, a bed of straw being placed between each cheese. It is now that it improves owing to the mould which develops on the surface.

Fresh, non-fermented cheeses are made with cow's milk. They comprise *cheese à la pie* (fresh white), made with skim milk, and the fatty cheeses of Savoy, Gournay, Viry, Switzerland or Neufchatel. They contain from 50 to 60 per cent. of water. They are rich in fatty matters.

In the ripening of cheese, a part of the casein is peptonized, as we have said, at the same time as leucins and tyrocins, etc., are formed, and often carbonate of ammonia, at least on the surface. A part of the casein is even transformed into a coagulable substance by heat (Duclaux). At the same time very sapid and odorous products appear which give to each kind of cheese its aroma and taste. They vary with the nature of the micro-organisms which slowly bring about the ripening of the curd ; the secret of the cheese-maker consists in retaining the best possible of those cryptograms which he has recognized as being the most fit to develop the special taste of these preparations, and to stop the intervention of harmful agents, of vibrios in particular.

During the ripening, the milk-sugar in fermenting, the fats in being partially saponified under the influence of special ferments and of surrounding diastases, yield glycerine, alcohol[1] and fatty acids which are saturated by the amines and ammonia formed at the same time. The fatty matter changes thus little by little into compounds soluble in alcohol and carbon disulphide which potash distends and gelatinizes, and which absorb slowly the oxygen by colouring in the air.

The tables on the following page give the composition of the most valued cheeses.

Cheeses are excellent adjuvants of food. They are also peptogenic and stimulants of the digestion. It has been stated that they increase the percentage utilization of the albumin absorbed, and that they aid the assimilation of fats and carbo-hydrates. Cooked cheeses as Emmenthaler, Parmesan, etc., may add to our daily alimentation an important contribution of easily assimilable nitrogenous matters ; they can be partially substituted for milk in the milk diet. But the fermented cheeses of strong taste (Roquefort, Gorgonzola, Munster) are not accepted by all stomachs and could not be substituted for milk, nor, as a rule, given to invalids.

[1] The traces of alcohol in Roquefort are larger.

CHEESE

PERCENTAGE COMPOSITION OF THE PRINCIPAL CHEESES.

	Emmenthalen or Gruyère (average).	Parmesan (average).	Chester.	Cantal of 8 months.[1]	Dutch (average).
Water	34·68	31·80	35·92	36·26	36·60
Casein	31·41	41·19	25·99 }	} 24·59	28·21
Albumin . . .	—	—	— }		—
Matters soluble in boiling water	1·13	1·18	7·50 }		2·50
Fatty bodies . .	28·93	19·52	26·2	34·70	27·83
Soluble mineral salts [2]	} 3·85	6·31	4.16	2·23	} 4·86
Insoluble mineral salts				2·22	
Authors . .	Müller	J. Koenig	Payen	Duclaux	Payen ; Mayer

	Roquefort (2 mos.).	Gorgonzola (average).	Camembert (average).	Brie (average).	Neufchatel (called Swiss).
Water	19·30	37·72	51·30	49·79	37·87
Casein . . . } Albumin . . . }	43·28	25·91	19·00	18·97	17·43
Matters soluble in boiling water	1·50	0·23	3·50	0·83	—
Fatty bodies . .	32·30	32·14	21·50	25·87	41·30
Mineral salts . .	4·45	4·00	4·70	4·54	3·40
Authors . .	Blondeau	J. Koenig	Malagutti	Various authors	Malagutti

[1] The curd from which Cantal cheese is obtained contains, according to Duclaux : water, 40·70 ; fats, 30·10 ; casein, 20·0 ; coagulable albumin, 4·10 ; matter soluble in warm water, 4·30 ; salt, 0·80.

[2] These soluble salts are principally formed of alkaline phosphates ; the insoluble of phosphate of lime, with a little magnesia, oxide of iron and of silicon.

XVIII

EGGS AND MILTS—FATTY BODIES

IN terminating the history of the derivatives of milk, it remains to speak of butter, but we will defer the study of it to the end of the chapter so as not to separate it from the other fatty bodies. First, in order to complete the description of the aliments furnished by the animal world, we will occupy ourselves with eggs and milts.

EGGS.

Eggs of the gallinaceous tribe, especially those of the hen, enter, as one knows, into a large part of domestic food. Paris alone consumes more than 500,000,000 of eggs per year.[1]

A hen's egg weighs on an average 60 grms., thus more than 30,000 tons of eggs are consumed yearly.

The egg is composed of its shell (with its shell membrane), of white or albumin and of the yolk.

These three principal parts are in the case of the hen's egg, in the following average weights :—

	Average Weight.	For 100 parts.
Shell	7·2 grms.	12
Albumin	35·4 ,,	59
Yolk	17·4 ,,	29
	60·0 grms. for an egg.	100

The albumin or *white* of the egg is essentially formed of a proteid material, ovalbumin, mixed with a little ovoglobulin, another soluble albuminoid by virtue of the alkaline salts of the white, and of a weak proportion of a proteid material analogous to fibrinogen (*A. Gautier*), a substance which, like the latter, coagulates by agitation. These three proteid bodies, mixed with an excess of water, are contained in little cells formed by the small membranules which divide and enclose the albumin.

[1] 538,000,000 of eggs or 32,000,000 of kgs. were declared by the octroi of Paris in 1900.

It is known that, raised to 70° or 80°, the albumin of the egg coagulates and becomes white, opaque and insoluble.

Its average composition is as follows :—

Water	85·5
Albuminoid matters	11·8
Membranules (about)	1·0
Extractives	0·3
Glucose	0·5
Fats	0·25
Mineral matters	0·61
	100·0

A hundred parts of mineral matters left by incineration of the white of egg contain, according to Poleck and Weber :—

NaCl	9·16–14·07	Magnesia	1·60– 3·17
KCl	41·29–42·17	Oxide of Iron	0·44– 0·55
Soda (not united with Cl)	23·04–16·09	P^2O^5	4·83– 3·79
Potash „ „ „	2·36– 1·15	SO^3	2·63– 1·32
Lime	1·74– 2·79	SiO^2	0·49– 2·04
		CO^2	11·60–11·52

In the ashes of white of egg we notice its richness in potassium, the existence of alkaline carbonates coming in part from the pre-existing carbonates, in part from the decomposition of the albuminates ; the preponderance of magnesia over lime, and the presence of iron and silica, the latter in a relatively very large quantity.

The *yolk of egg* is essentially composed of fatty matters of which some are nitrogenous and phosphorous, *the lecithins*, and of special albuminous substances, vitelline and nucleo-proteids, which remain insoluble when the yolk is treated with a mixture of water and ether. The vitelline is separated from the nucleo-proteids by means of slightly salted water which dissolves it. It has the property of splitting up under the influence of warm water into a coagulated albuminoid material (75 per cent.) and lecithin (25 per cent.). With regard to the nucleo-proteids, which are not dissolved by the solution of salt, their digestion by the gastric juice shows that they are formed of albuminoids free from phosphorus and of cytoproteids and nucleo-proteids, richly phosphorated. The yellow of egg is then an abundant source of assimilable phosphorus.

By the side of these proteids of vitelline, it is necessary to point out the *hematogen* of Bunge, a material rich in organic iron destined to furnish this element to the blood of the new being.

The fatty matters of yolk of egg are formed of a mixture of olein and margarine with a small quantity of lecithins, of cholesterin, etc. These lecithins of which, in a free or combined state, an egg contain up to 2 grms., are complex nitrogenous matters

formed by the association of phosphoric acid, fatty acids, glycerine and neurinic bases. They play an important part in the assimilation of the phosphorus. According to the observations of different authors, but which have been contested, they even stimulate assimilation in general.

In the case of fish in the spawning season, the lecithins appear in abundance in the eggs, while on the contrary the muscular masses disappear.

The percentage average composition of the yolk of egg is as follows :—

Water	51·03
Albuminoids	16·12
Fatty substances	31·39
Soluble non-nitrogenous matters	0·48
Salts	1·01

In the 31·39 per cent. of fatty substances in the yellow of egg we find 8·43 of lecithins and 0·30 of cerebrin. The egg also contains a little glucose and two colouring materials, soluble in cold alcohol; the one free from iron which appears to resemble the biliary bodies, the other more ferruginous which resembles hematoidin. The following is the percentage composition of the yolk of hen's egg :—

	Gobley.	Schützenberger.
Water	51·49	48·55
Vitelline and other proteid matters	15·76	13·93
Soluble albumin		2·84
Insoluble membranes	—	0·46
Margarine and olein	21·30	31·85
Cholesterin	0·44	
Lecithins	8·43	
Cerebrin	0·30	
Alkaline chlorides and sulphates	0·277	1·52
Ammoniacal salt	0·034	
Phosphates of lime and magnesia	1·022	
Colouring matters (with iron)	0·553	
Glucose		

If we now calculate the nutritious materials contained in an egg weighing on an average 60 grms. (with its shell), we shall have in useful materials :—

Organic Matter of a Hen's Egg.

Albuminoids of the white	4·5	12·7 grms.
Vitellines, nucleo-albumins of the yolk [1]	2·6	
Fats of the yolk	4·1	
Lecithins	1·5	

[1] Of which lecithins by decomposition = 0·5 grms. Total lecithins for an egg = 2 grms.

For 100 parts of egg without its shell, we shall have :—

	Hen.	Duck.
Water	73·67	71·11
Nitrogenous matters	12·55	12·24
Fats	12·11	15·49
Non-nitrogenous substances	0·55	—
Mineral salts	1·12	1·16

By reason of its albumins, fats, phosphorated organic bodies and its iron, an egg, like muscular tissue and even more so than the latter, is suitable for providing a young animal with the materials essential to the formation of its blood, muscles and nervous tissues. Thus, fresh eggs, boiled or buttered, form an aliment essentially assimilable, reparative and easily digested.[1]

The shell of the egg is porous. It has been recognized that it allows some microbes or spores of mould to pass through, after being kept a long time. It is also known that the odorous materials and vapours pass through it easily, and can transmit to the egg their defects or their qualities.

Eggs of Fish.

They compose a very small part of ordinary food; the following is the composition of carp's and chad's eggs for 100 parts :—

	Carp (Gobley).	Chad (O. Atwater).
Water	64·08	72·1
Vitellin	14·06	23·4
Fats	2·57	3·8
Cholesterin	0·27	—
Lecithins	3·05	—
Extractive matter	0·39	—
Membrane and envelope	14·53	—
Colouring matter and iron	0·031	—
Mineral salts	0·82	1·6

Caviare is much eaten in the North of Europe; it is formed of slightly salted eggs of the sturgeon, and of some other big fish.

It is composed on an average, according to the analysis of Payen, Lidow and Stützer, as follows :—

Water, 43·89; nitrogenous matter 30·79; fatty substances, 15·66; organic non-nitrogenous matter, 1·67; mineral salts, 8·09 per cent. (with 6 parts of ordinary salt added).

It is a very phosphorated and exciting substance which con-

[1] It has been possible to make preparations of fresh eggs dried in vacuo. They only contain 6 to 7 per cent. of water (Effner).

valescents and those suffering from gastralgia support remarkably well.

"La boutargue," (des Provençaux) is a condiment highly appreciated, composed of the eggs of the mullet, preserved in their natural membrane and dried in the sun.

MILT.

By the side of the eggs of fish, one must mention their milts (seminal fluid of male fishes) which are richer than fish eggs in nitrogen, and in organic phosphorated substances.

In the ripe milt of the salmon, Miescher found after dessication :—

Protamins	26·76
Nucleins	48·68
Albumins or Nucleoalbumins	10·32
Lecithins	7·47
Cholesterins	2·24
Fatty substances	4·53

The protamines of Miescher, which largely enter into these alimentary products, are bases which Kossel considers like the most simple albuminoid matters. In uniting themselves to the nucleinic acids they form *chromatines*, the principal phosphorated substances of cellular nuclei.

The milts of fish are perhaps the most nutritive aliment and at the same time the richest in phosphorus that is known.

FATTY BODIES—FATS AND OILS.

Whether they are borrowed from the animal or vegetable kingdom, the analogy of constitution prevents the separation of butters, fats and oils. The study of them will serve us as a transitory stage to pass from animal aliments to those furnished to us by plants.

We know that fatty bodies are formed by mixtures, in variable proportions, of different fatty principles mutually dissolvent (*Chevreul*). These fatty principles are all true ethers resulting from the union of a like alcohol, glycerine with three molecules of fatty acid or the isologs of these fatty acids (butyric, stearic, margaric . . . oleic acids, etc.) with elimination of three molecules of water.

The butyrin, margarin, stearin and olein of our fats can in their turn be split up by hydrolysis and made to give back, thanks to the action of the water assisted by alkalies or saponifying ferments, the glycerine and fatty acid of which they contain the radicals. For example :—

$$C^3H^5\begin{cases}OC^4H^7O\\OC^4H^7O\\OC^4H^7O\end{cases} + 3H^2O = C^4H^5\begin{cases}OH\\OH\\OH\end{cases} + 3C^4H^7O{,}OH$$

Butyrin of butter Glycerine Butyric acid

Along with these properly called fatty principles, we can find in the fats and oils a small quantity of free fatty acids and some phosphorated bodies, colorants, odorants, etc. The usual fats and oils all have a very analogous percentage composition :—C = 76 to 77 ; H = 11 to 12 ; O = 11 to 13 per cent.

The tables which I have already given (p. 115 and following) show the amount of fat in the principal foods. Fat meats can contain (although very exceptionally) as much as 30 and 35 per cent. of their weight of it : lean meats from 1 to 6 per cent. ; brains 15 to 17 per cent. The vegetable aliments also furnish it in very variable proportions ; almonds, nuts, hazel nuts, cocoa as much as 50 and 67 per cent. ; cereals and vegetables in grains from 1·8 to 6·5 per cent. ; rice 0·8 ; green vegetables from 0·15 to 0·4 ; potatoes 0·15 per cent. Putting aside for the moment butter, of which we shall treat later, the principal comestible animal fats are :—

The fats of beef, mutton and pork are rich in stearin in the inner parts of the animal, in palmitin and olein in the outside parts and the skin. They have the average composition :—

	Beef Fat.	Mutton Fat.	Pork Fat.
Water	9·96	10·48	6·44
Membranes	1·16	1·64	1·35
Fat bodies	88·88	87·88	92·21
Ash	Traces	Traces	Traces

They contain in oleic and solid fatty acids combined, the following quantities for 100 parts :—

	Liquid Acids.	Solid Fat Acids.	Points of Fusion.
Beef fat	31	64	41°–49°
Mutton fat	15	80	42°–50°
Pork fat	49	41	33°
Goose fat	62	31	25°

The fat of goose and duck fusible at 24° or 26° is rich in butyrin and caproin.

The oils of fish in our climate are used more as medicines than aliments ; but the Esquimaux and Greenlanders consume them largely. In Russia, sturgeon oil is collected, melted and salted for use in the kitchen.

Cod liver oil is extracted from the livers of different *Gadus* which are left to themselves until by reason of a diastasic ferment which is produced in them, the oil separates out and swims

on the surface. It is also extracted directly by heating these livers in water or steam. Its density is 0·924. Besides the ordinary fatty bodies it contains some lecithins, some phosphorated and iodized substances, and some bases analogous to ptomaines. Dolphin's oil, which is used for imitations, is formed chiefly of trivalerine.

The principal *oils and fats* furnished by vegetables are the following :—

Olive oil obtained by pounding, with heat, the ripe food of the olive. Its density is 0·916 at 15°. It congeals at +2°. This oil is a greenish yellow, very fluid and of sweet taste. It is chiefly formed of olein and margarin with a little stearin.

Colza oil is extracted from the seeds of *Brassica campestris*. It solidifies at −6°·2. Density 0·913 at 15°. It is especially useful as lamp oil.

Rape-seed oil is extracted from the seeds of turnip-cabbage and turnip-radish. Density 0·915 at 15°.

Poppy oil is extracted from the seeds of *Papaver somniferum*. It solidifies at −18°. Its density is 0·925 at 15°. It is the oil which is vulgarly called *white oil*, although it is slightly yellow. It is often used as a substitute for olive oil on our tables.

Cotton oil, almost colourless, is extracted from the cotton plant and also used as a substitute for olive oil.

Oils of nuts and sweet almonds are also comestible. The first fluid, colourless, with a slight odour, easily grows rancid and has a density of 0·026 at 15°. It solidifies at −27°.

The alimentary fats and oils, after having been emulsioned and partly saponified in the intestines, are afterwards transformed, at least in a very large proportion, whilst traversing the intestinal walls, into the specific fats proper to each animal. However, by amply nourishing a dog with oil-cakes or seeds of colza which contain the glycerine of erucic acid $C^{22}H^{24}O^{2}$, a body entirely foreign to the tissues of this animal, Munk found again in its fats a certain proportion of this acid. Evidently, abundantly absorbed in the intestines, it had not had time to undergo completely the transformation into specific fatty principles proper to the canine species.

Fatty bodies are useful in the preparation of our aliments, but their absolute necessity as aliments has not been demonstrated. They can result, in fact, from the division of the albuminoids in the system and especially from the sugars and carbo-hydrates by loss of CO^2 and H^2O : $\underbrace{13C^6H^{12}O^6}_{\text{Glucose.}} = \underbrace{C^{55}H^{104}O^6}_{\text{Fatty bodies.}} + 23CO^2 + 26H^2O$.

In fact, two or three hours after a repast rich in starch and sugars, the quantity of carbonic acid gas expired and perspired increases considerably and in larger proportion than that of the oxygen absorbed in the same time (Hanriot). We have

seen (p. 56) that, of all the aliments, fats are those which, in the most feeble weights, introduce into the system the maximum of latent strength. Fats, like sugar and starch, are intended to provide the necessary energy for mechanical work and calorification. Fatty bodies being those of all the combustible principles stored in our tissues which disappear the first and the most easily, may be considered as foods "sparing" the albuminoids. However their action is less from this point of view than that of the carbo-hydrates; but we have said that, whatever be their relative abundance, ternary bodies could not entirely prevent the disintegration of the nitrogenous principles.

Fats and oils can be consumed in large quantities in very cold climates.

Butter.

Butter is separated from the milk by skimming and churning. Besides the ordinary fatty bodies, viz., olein, palmitin, stearin, it contains butyrin, caproin and caprylin and even a certain quantity of casein and traces of other albuminoids which the fatty globules carry away along with them; we also find some interposed water holding in solution lactose and salts borrowed from the serum of the milk. In solidifying, butter carries with it in a very large proportion, the microbic and diastasic ferments of milk; whence its liability to change and its facility for becoming rancid. Butter which has not been melted, but which is carefully washed and pressed, is less disagreeable because it is better cleared of the serum which remains interposed between the buttery globules.

By reason of this constitution and its very low melting point, 26°·5, butter is one of the most digestible of all the fatty bodies, especially if it is fresh. Spread on bread, one can consume it for some weeks without inconvenience, in a dose of 100 grms. and more per day. Here is, according to M. Duclaux (*Annales de l'Institut agronomique*, t. IX. 1884), the composition of fresh and salted butters made from cow's milk :—

	Fresh Butter.			Salt Butter.
	Cantal.	Isigny.		Isigny.
Water	13·40	14·24	12·40	12·36
Fatty matters	84·30	84·82	86·71	80·56
Salt	0·94	—	—	5·08
Milk-sugar	0·60	0·50	0·16	0·57
Casein and salts	0·76	0·44	0·73	1·43

The fatty material of butter of cow's milk gives on an average, the following composition according to W. Blyth :—*Olein*, 42 per cent.; *palmitin* with a little *stearin*, 50 per cent.; *butyrin*,

7·6 per cent.; *caproin* and *caprylin* 0·2 per cent. The butyric and caproic acids are there in the proportion of 1 to 2 per cent. according to Duclaux. Butter made from sheep's or goat's milk contains very nearly the same proportions of these various volatile fatty acids.

The colour of butter varies from white to an orange yellow, but its yellow tint is often due to anatto or to marigold or saffron which is added to it artificially.[1] The savour of butter is sweet, its odour very slightly perfumed. Its reaction should be slightly acid. Its free volatile acids vary from 0·10 grms. to 0·25 grms. per kg. The different pastures and breeds of cows introduce notable variations into the organoleptic properties and into the composition of butter. If the animal has been fed in the stable on malt, oilcakes, etc., its milk and butter will have a disagreeable flavour. If also these foods are given abundantly to the animal, a part of their fatty principles non-transformed may be found in the butter.[2]

It is often adulterated. Most generally suet, horse fat, oleo-margarine and artificial margarine of which we shall speak farther on, are introduced into it. Or else turned or rancid butters are re-melted and made into an emulsion with a little milk and water charged or not with antiseptics and a little bicarbonate of soda, etc.; it is then submitted to centrifugal force which reunites the fatty globules thus cleansed. They are afterwards consolidated by being made to circulate in very narrow conduits under strong pressure. It only remains to colour the butter thus purified and to perfume it very slightly with nut oil and sometimes a trace of essence of bitter almonds.

The fat of kidneys, of intestines or of calves, ox or sheep's tails melted at a mild temperature combined with olein or the oil of sweet almonds and mixed with a little fresh butter finally malaxated and centrifugalized, allows of a fairly successful imitation of butter being made.

Margarin.—A kind of fat imitating well natural butter is made under the name of margarine. The fatty parts of the internal organs of the ox, of the calf and even of the sheep are collected in a fresh state, hashed, cleansed and melted at 48° to 50° whilst working them up under water. The fats thus purified and deprived of their membranes, are decanted and cooled to 30° until the stearin is crystallized. The mass is then submitted to great pressure which carries off the excess of this latter substance and leaves a more fluid material, oleo-margarine. This is sent in forced jets through fine tubes into receivers where

[1] Sometimes with dinitrocresol and Martius' yellow which are poisonous bodies.

[2] Lebedeff; Munk. *Centralblatt f. deutsche med. Wiss.*, 1882; *Virchow Arch.*, t. 95, p. 416.

it is divided and forms an emulsion which is mixed with a little fresh milk and then coloured yellow with roucou, and churned.

An artificial butter is thus obtained which washed and strongly compressed, appears similar to ordinary butter.

Margarine well prepared with choice fats much resembles real butter. It is less changeable and more unlikely to become rancid. It is a good preparation when sold under its real name and used to replace butters of inferior quality.

Its average percentage composition is :—*Palmitin*, 22·3 ; *stearin*, 46·9 ; *olein*, 30·4 ; *butyrin* and *caproin*, 0·4.

XIX

ALIMENTS OF VEGETABLE ORIGIN—CEREALS

THE study of the modes of alimentation of great human communities permits us to state (pp. 13 and 27) that allowance being made for drinking water, out of 100 parts of aliment, man in our climate borrows about 77 parts from the vegetable kingdom.

The vegetable aliments therefore play a very important part. The most necessary of them, bread (or similar foods) enters into our ordinary allowance to the extent of 21 per cent. After it, the most common aliments of vegetable origin are the cereals and their derivatives, herbaceous or seed vegetables, roots, tubercles, fruits proper.

Although vegetables bring us the same sorts of fundamental alimentary principles as those furnished to us by animal foods, albumins, fats, carbo-hydrates, these principles differ however in the details of their internal constitution. Besides, in plants they are mixed with a mass of cellulose material almost inassimilable by man; and whereas in the aliments of animal origin, proteid materials predominate, it is the starchy materials and sometimes the sugars which are found in great abundance in the vegetable aliments.

Let us also remark that meat, milk, eggs, blood, etc., provide us with their albuminoids almost in the same state in which they exist in our organs, and that on the contrary vegetable albumins such as legumin, almond, gluten, etc., further removed from the state which they must reach in the animal to enter into the constitution of its organs, demand, in order that we may use them, a more difficult work of assimilation if one judges of them, on the one hand, by the accepted belief that they nourish less for the same weight, that they are less fit to keep up our strength; and if one remembers, on the other hand, that they are less completely and more slowly re-absorbed in the intestinal tube. According to Rübner, whereas out of 100 parts of proteid substances furnished by meat, 96 are utilized by man, 80 only are utilized if these albuminoids come from wheat and 82 if they are furnished by peas and other dry vegetables.

It is almost the same with the ternary matters: the animal provides us with them to a very large degree in the state of imme-

diately assimilable fats ; the plant brings them especially in the form of sugared or starchy substances, which, before changing into fats in the system, have to undergo a loss of carbonic acid and water. Besides, a part of these starchy substances and a great part of the cellulose and analogous compositions (gums, mucilages, etc.) pass through the animal's intestine without having time to become either transformed or even absorbed. Out of 100 parts of carbohydrates contained in different ordinary aliments, Hubner has found that the following proportions remained in the fæces :—

White wheat bread	1·1
Rye bread	10·9
Maize	3·2
Rice	0·9
Potatoes	7·6
Carrots	18·2
Lentils	3·6—7

A very important part of the cellulose of herbaceous vegetables passes through the intestines without being absorbed : only a slight proportion of it is utilized.

With regard to the vegetable fats, they are in general as easy to assimilate as the animal ones. One finds along with them in plants some bodies of a fatty nature, more or less soluble in ether and alcohol, but of a different constitution. They are often phosphorated and nitrogenized. Instead of dividing by hydrolysis like true fats into glycerine and fatty acids, certain of these substances give glycerine, fatty acids, phosphoric acid and nitrogenous bases ; this is the case with the *lecithins.* According to Schultze and Stieger, the contents of the grains of cereals in lecithins varies from 0·52 to 0·74 per cent.

Other substances of a fatty appearance are the true nucleins ; phosphorus exists there in an organic and easily assimilable state. Seeds and tubercles are very rich in this element. Nearly two-thirds of that which we consume, comes from these substances. It exists there *in a very small quantity* under the form of mineral phosphorus ; only 6 per cent. of total phosphorus is found there under the form of lecithins and nucleins ; but the greater part (from 70 to 92 per cent.) is again found under the form of a simple combination, the anhydroxymethylenediphosphoric acid discovered by M. Posternack[1], a body corresponding to the composition $C^2H^8P^2O^9$ and clearly decomposed by hydrolysis into inosit and phosphoric acid. This acid contains, *in the organic state* 26 *per cent. of phosphorus.* In the seeds it appears united to potash and magnesia.

The following table, borrowed from M. Posternack, indicates

[1] *Compt. rend. Acad. sciences,* t. CXXXVII, pp. 339, 439.

the percentage quantities of phosphorus existing in some seeds under these different forms :

	Total. P.	P. of Posternack's Acid for 100 parts of Grain.	P. of Posternack's Acid for 100 parts of total P.	P. of lecithins for 100 parts of total P.
Hempseed shelled	1·460	1·330	91·44	1·02
Peas	0·367	0·260	70·80	6·2
Lentils . . .	0·299	0·247	82·60	6·7
Haricots . . .	0·512	0·418	81·60	8·0

The extracts and flours of cereals introduce into the system a large quantity of phosphorus in an assimilable form, without burdening the alimentation with an excess of albuminoids or nitrogenous waste. These extracts are also favourable to the growth of young animals, and excellent for convalescents and infants as has already been remarked by the ancient Greek physicians.

The following table, due to MM. Schlagdenhauffen and Reeb[1], gives in phosphoric anhydride P^2O^5, the relative proportion of phosphorus contained in the natural alimentary seeds under two forms—mineral and organic.

	Ash.	P^2O^5		
	per 100.	Mineral.	Organic.	Total.
Wheat . . .	2·22	0·859	0·183	1·040
Rye . . .	2·16	0·739	0·291	1·030
Barley . . .	2·42	0·557	0·373	0·930
Oats . . .	3·29	0·680	0·160	0·840
Buckwheat. .	2·97	1·648	0·070	1·718
Haricots . .	3·13	0·652	0·187	0·839
Peas . . .	2·73	0·581	0·240	0·821

Plants also introduce into our food a certain quantity of iron, magnesia, manganese and, without doubt, some silica in organic form. Several of their combinations also contain phosphorus soluble in ether and even in petroleum ether.[2]

Vegetables, particularly herbaceous vegetables and seeds of leguminosae, play another very important part in alimentation. They convey to the animal organism in the form of salts of potash, soda, magnesia and lime, the basis necessary to our tissues. They are contained in plants in the form of albuminates, malates, citrates, tartrates, oxalates, etc. The organic material of these

[1] *Comptes Rendus*, t. CXXXV, p. 205.

[2] In my researches on chlorophylls, I have shown that these vegetable pigments dissolved in petroleum ether contain a certain quantity of phosphorus and magnesium ; after evaporation and calcination, we obtain a residue containing phosphate of magnesia free from iron.

salts during destruction in the system owing to a series or oxidations, gives up in the form of alkaline carbonates, the bases introduced in the form of organic salts. They saturate the uric, hippuric, lactic, sulphuric, phosphoric acids, etc., arising from the dissimilation of animal matters. It is chiefly by this mechanism that the alkalinity indispensable to their functioning is preserved in our tissues and plasmas. From this point of view, vegetables play in animal alimentation a rôle of the first importance. Potash predominates in them; according to Boussingault, spinach contains 4·5 grms., potatoes 3·2 grms., turnips, 3·7 grms., cabbages 2·6 grms. chicory 1·7 grms., etc., for 100 dry parts.

Out of the 4·5 grms. of potash (K^2O) and 1·1 grm. of soda (Na^2O) contained in his alimentary allowance for 24 hours, an adult receives from vegetables 3·2 grms. of potash, and 0·65 grms. of soda. Out of 1·15 grms. of lime and 0·65 grms. of magnesia in the same allowance, vegetables furnish him with 0·80 grms. of lime and 0·50 grms. of magnesia.

We eliminate each day by the urine about 5 grms. of sulphuric anhydride (SO^3) and 2·5 grms. of phosphoric anhydride (P^2O^5) arising from the sulphur and phosphorus of the albumins and nucleins. It is the acids thus formed, part by division and part by oxidation, which are saturated by the alkalies furnished by the plants. To this saturation, however, a feeble proportion of ammonia directly formed in the tissues contributes. This latter phenomenon, summary in the case of omnivorous animals, develops largely in carnivorous animals nourished solely on flesh.

Classification of vegetable aliments.—We shall divide into five groups the aliments furnished by plants:

(*a*)—*Cereals* (meals, bread, etc.) and their derivatives.

(*b*)—*Seed vegetables* (haricots, peas, lentils, beans, etc.).

(*c*)—*Roots and tubercles* (potatoes, batatas, yams, Jerusalem artichokes, etc.).

(*d*)—*Herbaceous vegetables* (spinach, sorrel, chicory, cabbages, salads, etc.).

(*e*)—*Fruits* (apples, pears, peaches, strawberries, almonds, nuts, etc.).

Cereals.

The seeds of cereals are used in foods either in a direct form cooked in water after removing the husks and consumed in their natural state as barley, rice and corn itself, or else in the form of *pap* or *dough* as in the case of maize and buckwheat, or finally and generally in the form of bread. Before speaking of this last preparation, we state in the following table, composed solely of averages borrowed from J. Koenig[1] and each one corresponding

[1] *Loc. cit.*

to a great number of analyses, the composition of the *entire grain* of the principal cereals :

AVERAGE COMPOSITION OF GRAIN OF THE PRINCIPAL CEREALS.[1]

	French Wheat (av.).	Russian Wheat. (av.).	American Wheat Winter Corn (av.).	American Wheat Summer Corn (av.).	Rye (av.).	Barley (av.).	Oats (av.).	Maize (av.).	Rice (av.).	Buckwheat (av.).	White Sorgo (Balland).
Water . . .	13·37	13·37	13·37	13·37	13·37	14·05	12·11	13·35	12.58	14·12	11·70
Nitrogenous substances	12·64	17·65	11·60	12·92	10·81	9·66	10·66	9·43	6·73	11·32	9·32
Fats . . .	1·41	1·58	2·07	2·15	1·77	1·93	4·99	4·29	0·88	2·61	2·25
Starches and sugars	68·92	65·74	69·47	67·98	70·21	66·99	58·37	69·33	78·48	54·86	67·63
Celluloses .	2·00		1·70	1·72	1·78	4·95	10·58	2·29	0·51	14·32	6·20
Ash . . .	1·66	1·66	1·79	1·86	2·06	2·42	3·29	1·29	0·82	2·77	2·90

We see that rice is the cereal richest in starchy matters : after it comes, in decreasing order, rye, wheat, maize, and lastly buckwheat.

Maize and oats are the richest in fatty matters, rice the poorest.

Of all the cereals, wheat is the one which contains the most assimilable proteid matters (up to 18 per cent.) ; after that comes buckwheat (11·6 to 17 per cent.), then rye, barley and oats (10·7 per cent.) The poorest are maize, sorgo, and especially rice (6·7 per cent.).

After being ground and passed through a bolter to separate out the germs, the bran and a small proportion of complex nitrogenous materials, the different grains of cereals give flours of which the following table indicates the *average composition* according to J. Koenig :—

AVERAGE PERCENTAGE COMPOSITION OF FLOURS OF CEREALS.

	Flour of Wheat (average).	Flour of Rye.	Flour of Barley.	Flour of Oats.	Flour of Maize.	Flour of Buck-Wheat.
Water	13·37	13·71	14·83	9·65	14·21	13·51
Nitrogenous matters	10·21	11·57	11·38	13·44	9.65	8·87
Fats	0·94	2·08	1·53	5·92	3.80	1·56
Starches and sugars	74·71	69·61	71·22	67·01	69.55	74·25
Celluloses . . .	0·29	1·59	0·45	1·86	1·46	0·67
Ash	0·48	1·44	0·59	2·12	1·33	1·14

Wheat and buckwheat give the flour richest in starch ; oats contain most albuminoids, principles in which buckwheat and rice are the most destitute. The flour of oats and maize are the

[1] See the analyses of Péligot (*Ann. phys. chim.* 3rd series, t. XXIX, p. 34. on the composition of the different kinds of wheat.

richest in fats in which, on the contrary, the flours of wheat and especially rice are the poorest.

A propos of wheat flour, we shall presently give a few facts concerning the proteid materials of cereals. As for the fatty substances in part phosphorated and nitrogenous, they are above all formed from ethers of glycerine, of fatty acids, of free fatty acids, and finally of lecithins accompanied by others phosphorated bodies and of special cholesterins. The quantities of phosphorus found in the ethereal extract in 100 parts of dry flours have been according to E. Schultze and E. Steiger :

Wheat	0·025 grms.
Rye	0·022 „
Barley	0·028 „

We know that cereals form the basis of human alimentation. Unfortunately some of them introduce poisonous principles into the system. Rice often contains moulds whose spores are not destroyed by cooking ; maize can provoke pellagra, at least in countries where this grain is largely consumed by the people ; rye is dangerous by reason of its ergot, which is liable to produce gangrene of the extremities ; the flour of wheat may contain venomous seeds of rye grass (*Lollium temulentum*) and of corn-cockle (*Agrostemma*). It is possible by a good choice of grains to avoid these poisonous effects which are sometimes endemic.

Wheat.

The varieties of wheat are very numerous : winter wheats, summer wheats, hard wheats and tender wheats or lammas wheats, etc. They differ in their average composition : winter wheats are poorer in gluten and richer in starch ; hard wheats are more charged with both and less aqueous.

In general, gluten varies in the grain of wheat from 10 to 15 or 16 per cent. ; on an average 12 per cent. The soluble albumins vary from 1·3 to 2·6 per cent. ; on an average 1·8 per cent. ; the weights of the assimilable albuminous materials of this precious grain rise on a general average to 13·5 per cent. But in Germany the ordinary weight of the albuminous bodies of different sorts of wheat rises only to 11·6, and in France to 12·6 per cent. The starch in a grain of wheat varies from 60 to 73 per cent. in Germany and from 62 to 74·5 per cent. in France.

The *hard wheats*, with smaller grains, as it were corneous and somewhat translucid, come from the warm countries (South America, Africa, Asia, Spain, Italy). They are used in making oatmeal, dough, macaroni, semolina. These are the grains of cereals richest in nitrogenous matter. They yield from 82 to 83 per cent. of a yellow flour giving from 140 to 143 kgs. of bread for 100 of flour and for 122 of grain. The *tender wheats* are the poorest in proteid materials. Their flour is whiter and

more starchy. They furnish bolting from 72 to 78 per cent. of a flour which gives per 100 kgs., 130 to 136 kgs. of bread[1].

Here is the composition of two average samples of flour of wheat, spoken of as " of the first and second quality " :—

	First.	Second.
Water	13·34	12·65
Gluten	10·18	11·82
Fatty matters	0·94	1·36
Starch	74·75	72·23
Cellulose	0·31	0·98
Mineral matters	0·48	0·96
	100·0	100·0

The very white flours, obtained from tender wheats and groats by crushing in cylinders called Hungarian, which separate and cast the heart of the grain, are much less rich in gluten than the flours classed as being of the second quality, on account of their being less white. The first qualities are also poorer than the second in phosphorus and mineral elements. It follows that the commercial denomination of " first quality flour " and " second quality flour " indicates the inverse of the nutritive value of these products.

Bran, which is sometimes left in bread for economy or for pretended motives of hygiene to which we shall refer again, has the following composition which I compare with that of the corresponding flour :

	Flour.	Bran.	Bran of a Flour bolted to 20% according to Poggiale.
Water	15·54	12·67	12·67
Nitrogenous matter, soluble	11·17	12·99	5·61
Nitrogenous matter, insoluble			7·38
Fats	1·07	2·88	2·88
Starch	70·43	31·31	21·69
Dextrins and sugars	—	—	9·61
Cellulose	0·98	34·67	34·57
Ash	0·81	5·58	5·51[2]
	100·00	100·00	

[1] On an average 100 parts of wheat give by grinding :—
70 per cent. of very white flour
5 per cent. of brown flour
22 per cent. of bran
3 per cent. of waste
100 kgs. of corn give on an average 96 kgs. of fresh bread.

[2] This analysis proves that bran contains half its weight of assimilable matter, of which 10 to 12 per cent. are nitrogenous substances.

The cellulose of grain is, as we can see, almost entirely contained in the seed coat.

For 1,000 parts, the grain of wheat contains, on an average, 17 parts of mineral matters, 8 of which are phosphoric acid. 1,000 grms. of flour give no more than 5·5 parts of mineral salts, 2·50 of which are phosphoric acid. It is the bran which has carried off this enormous quantity of phosphates.

For 1,000 parts of grain the phosphorus is thus divided :—

Whole grain, 21p. of mineral salts of which 8·93 are P^2O^5.

Flour, 5·5p. of salts of which 2·33 are P^2O^5.

Bran, 15·5p. of mineral salts of which 50p. 100 are phosph. of K Mg, Ca.

The average ash left by combustion of wheat has, according to E. Wolff, the following percentage composition :—

	Winter Wheat. (110 analyses).	Summer Wheat. (16 analyses).
Potash (K^2O)	31·16	30·51
Soda (Na^2O)	3·07	1·74
Lime (CaO)	3·25	2·82
Magnesia (MgO)	12·06	11·96
Ferric oxide (Fe^2O^3)	1·28	0·51
Phos. acid (P^2O^5)	47·22	48·94
Sulphuric acid (SO^3)	0·39	1·32
Silica (SiO^2)	1·96	1·46
Chlorine	0·32	0·47
	100·70	99·73
Total ash for 100 parts of wheat	1·96	2·14

This ash is then almost entirely composed of phosphate of potassium (PO^4K^2H) and phosphate of magnesia (PO^4MgH) with very small proportions of soda, chlorine and lime. It is always acid to litmus paper. A part of its phosphoric acid proceeds from the nucleins and the oxidation of organic phosphorus. One will also remark the extraordinary richness of these ashes in silica.

The principal nitrogenous matter of flour, gluten or vegetable fibrin, is composed of four bodies : *gluten-casein*, the true vegetable casein insoluble in alcohol[1], and three other albuminoids

[1] We find in the flour of cereals and of leguminosae, a globulin crystallizable like its salts, *edestan*, it is soluble in slightly salted water, which cold water and dilute acids transform into an insoluble modification in the solutions, and which possesses basic properties : it is the *edestin* of Osborne. It dissolves in weak alkalies and combines with acids, particularly phosphoric acid with which it is in combination in these grains. *Edestin* is precipitated from its solutions by an excess of NaCl. It is acid to phenolphthalein. It dissolves in dilute acids and forms with them and with alkalies true combinations (see *Bull. Soc. Chim.*, 3rd Series, t. XXVIII, pp. 186, 189, 303, 393, 395, 666, and t. XXX, p. 274).

soluble in this dissolvent, which are: *gluten-fibrin*, insoluble in water; *gliadin* which is separated by boiling water, and the *mucedin*. A *vegetable albumin* soluble in cold water accompanies the gluten; it is very analogous to the albumin of egg.

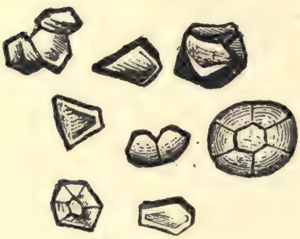
The starch of wheat is made up of grains from 49 to 50μ. in diameter and has a special form (Fig. 8). It enables us to recognize this flour under the microscope and to distinguish the fraudulent additions of rice, barley, oats, fecula, potatoes, etc.

The fatty material extracted from flour of wheat by ether is easily fused at about 30°.

It contains some lectihins and other nitrogenous or phosphorated compounds, in particular methylene-diphosphoric acid $C^4H^8P^2O^9$ of M. Posternack, to which we shall return when speaking of mineral aliments.

These data concerning the flours of wheat apply to a large extent to the flours of other cereals of which we shall only say a few words before studying bread—their chief industrial product.

Wheat Starch.



Rice Starch.

Grains of Potato Starch.

FIG. 8.

RYE, BARLEY, OATS, MAIZE, RICE, BUCKWHEAT.

Rye.—More recently discovered than corn, this grain enters into the alimentation of many countries. Rye is indeed the cereal which sprouts in the poorest soils. Its gluten cannot be extracted from this flour by kneading with water.

Rye gives a brown bread, slightly sourish, lightly hygroscopic and of a rather sweet and peculiar odour. It is capable of being preserved without hardening and it is in this that its chief advantage lies. It is a little more difficult to digest than wheat bread.

We here give the analysis, according to J. Koenig, of bread made from flour of sifted rye (ordinary rye bread) and non-sifted (Pumper nickel of the Germans).

Rye.	Rye Bread.	Pumpernickel.
Rye bread	42·27	43·42
Nitrogenous matters	6·11	7·59
Fats	0·43	1·51
Sugar	2·31	3·25
Starch	46·94	41·87
Cellulose	0·49	0·94
Ash	1·46	1·42

The mixture of flour of rye and wheat forms *meslin*, which produces a bread easy to keep and of fairly good taste.

The consumption of rye bread made with flour coming from grains invaded by the *Claviceps purpurea* or *ergot of rye*, can produce epidemics, characterized especially by gangrene of the extremities.

Barley.—This plant is valuable by reason of its rapid growth : four months suffice for its ripening. It can be cultivated in the coldest or hottest countries.

The flour of barley is little valued—one knows the saying : *rough as barley bread*. However, we sometimes mix, for economy, the flour of barley with that of wheat. Thus we obtain a bread which rises badly, is of less agreeable taste than that of wheat alone, and above all, more indigestible.

Decorticated barley (barley meal), cooked in water with milk, with or without the juice of meat, makes rather a good aliment. Soups of barley or oats, by reason of their mucilages and swelling of the fecula, possess a gummy aspect (mucilaginous soups of the Germans) and contain only 1·5 per cent. of albuminoids and 5·5 to 5·6 per cent. of carbo-hydrates. They are useful for satisfying invalids without nourishing them much.

Oats.—Oatmeal, largely used in the form of soups and pies for 100 years in France, is no longer employed to-day except to prepare broths for children and weak persons, but it is used a great deal in England. These preparations are very slightly laxative. Oats are a somewhat exciting aliment ; they are the richest among cereals in fats, organic phosphorus and lecithins. It is said that the pap of oats is particularly used in the East to fatten young girls at the time of their puberty. If it is not perfectly ground and sifted, this flour may contain some husks and sharp hairs which hurt or irritate the stomach and intestines of children.

Oatmeal porridge is sufficiently nutritive, very stimulating, agreeable to the taste and has a slight perfume of vanilla.

Bread made from oats is very coarse and is only now consumed in very poor countries. Here is its average percentage composition :—

Water	13·04
Nitrogenous matters	8·39
Fatty matters	6·03
Sugar	4·09
Carbo-hydrates, etc.	60·12
Celluloses	5·28
Ash	3·05

Maize.—Maize or *Turkey wheat,* known from time immemorial, forms the basis of the alimentation of a multitude of countries, particularly Lombardy, the South-East of France, Turkey, Southern America, etc. Its yellow or white flour, according to the variety, cooked with water, into thick paps mixed or not with milk (*polenta* of the Italians) makes cakes of soft dough which are eaten instead of bread. Baked, this aliment is very easy to digest ; but 15 to 20 per cent. of its nitrogenous substances escape intestinal absorption. This cereal is also sometimes eaten in the form of seeds split by heating. Unfortunately the countries where maize is largely consumed, are those which suffer from pellagra.

Rice.—Rice (*Oriza sativa*) is the plant which affords nourishment to the greatest number of people in the world. It forms the basis of the alimentation of the yellow races of mankind ; it is also largely consumed in India, northern America and Europe. Its flour is unfit for making bread. Rice can only be eaten cooked in water, milk or broth, or in the form of gruel. It is occasionally consumed as bread, mixed with a considerable quantity of wheat flour. The pap of rice is an aliment easy to digest, especially when eaten almost dry, after the custom of the Japanese. Rice can be associated with milk, fatty bodies, a little meat or cheese. It gives with water a somewhat astringent decoction which is utilized in intestinal diseases.

Although the least rich of all the cereals in fatty and nitrogenous matters, rice added to a little pork or fish, serves as the nourishment of immense populations in China, Japan, India, etc.

It is a very prolific plant, but it can only be cultivated in rather warm climates and on lands which can be submerged, conditions which are unfortunately favourable to the development of paludial fevers.

Buckwheat.—Buckwheat or *blackwheat* is the grain of a plant belonging to the family of the polygonnæ which we obtain from central Asia.

It is to be found in most parts of Russia. In France it is consumed in Sologne, Brittany and in Normandy. Its crop in France is from 6 to 7 million metrical hundredweights. Its tetragonal

grain furnishes a whitish flour, unfit for making bread ; but some very substantial cakes and paps of rather agreeable taste are made from it. According to M. Balland, its flour contains from 9·4 to 11·5 per cent. of nitrogenous matters ; 2 to 2·8 of fatty substances and 58 to 63·5 of starch.

Decoctions of Cereals.—From all times decoctions of cereals have been used in medicine as drinks or light aliments for invalids ; some a srice water to arrest diarrhoea ; barley water or oats water as cooling draughts. This practice is perfectly rational. Not only do we thus obtain some sugared, salted, aromatized or alcoholized beverages which are pleasing to invalids, but which are also sufficiently nutritive by reason of the starchy and albuminous matters, but also salts and especially organic phosphorated salts of potash, magnesia and lime which they dissolve in small quantities. A decoction of 30 grms. of crushed barley or wheat per 1,000 cc. of water, boiled for one or two hours and filtered, contains per litre 0·11 grms. to 0·14 grms. of total phosphorus, of which 0·07 grms. to 0·09 grms. are organic phosphorus, part in the form of lecithins, part under the form of dissolved nucleins, part under the form of oxymethylenediphosphate of potash and magnesia (p. 210). These drinks, in the same way as milk, favour the development of the skeleton and growth of the child or convalescent, and sustain the invalid as Dr. Ch. Springer justly remarks in his little work, *The Energy of Growth*[1].

These decoctions of cereals can be employed very advantageously to combat demineralization in invalids and in wet-nurses to improve the quantity and quality of their milk. We shall return to this à propos of diets.

With these alimentary drinks we must mention toast and water, which is made with toasted bread boiled in water and afterwards passed through a sieve. It is a slightly nutritive drink by reason of its albuminous principles, its dextrin, sugar and salts and its organic phosphorated combinations.

[1] Paris, 1902.

XX

WHEAT BREAD

IN the two preceding chapters we have stated that it was indispensable to know about bread, pastes and paps made with flour other than that of wheat. We shall only concern ourselves in this chapter with bread made from wheat.

Bread is with meat the principal nutritive substance of the civilized white man. He has never tired of these two aliments. The total consumption of bread in Paris alone is 900,000 kgs. per day.

Bread is the result of kneading wheat flour with water and yeast, and baking this mixture.

The art of making bread has been perfected with the ages. *Raised* or fermented bread appears to come to us from the Egyptian who, already at the beginning of historical times, was eating raised bread and drinking beer[1]. From this country the use of leaven penetrated into Phœnicia, Greece, Italy and Gaul. But the ancient people of Rome ate corn either under the form of *pulmentum* or pap, as we still eat buckwheat or maize pap, and the *couscous* of the Arabs, or under that of unleavened cakes, cooked under the ashes or on the firebrands.

Flour of wheat (like all flour of graminaceae) when mixed and kneaded with water, a little salt and yeast, soon enters into fermentation: gases are produced—if it is a question of the dough of wheat or rye, the mass swells and becomes more or less porous and acidulated; it rises, as we say, and in order to make it into bread, it is only necessary to submit it to baking.

The leaven is sometimes formed of a part of the dough taken from a previous kneading and kept for some days, sometimes it is borrowed from the vat of the brewer. Leaven or specially

[1] The origin of leaven appears to be the sweetened juice of ripe grapes. In Egypt and Greece the juice of ripe grapes is kneaded with flour, and the whole dried in the sun under the form of little cones. There is thus obtained a preparation fairly easy to preserve, containing the mucors or yeast of the pellicle of the grape. Reduced to powder and mixed with sweetened liquids or with the bread mass, this powder caused its fermentation.

selected yeast[1], is mixed at first with a littl. water and fresh flour and kept for some hours at 20 or 50° (*first leaven*). This is in turn mixed with a sufficient quantity of flour and water (*second leaven*), and finally this second leaven is kneaded with the total amount of flour to be made into bread and the necessary water. The leaven is formed, as we know to-day, of a multitude of living microscopic cells, which, meeting in the dough some phosphates, nitrogenous soluble matters and sugars, develop there rapidly, especially at about 30° to 40°. By acting thus on the sugars of the flour, the leaven transforms them into alcohol and carbonic acid, and the gases thus produced in the heart of the dough tend to escape through the plastic mass, which they swell up and make porous and light. At the same time, under the influence of the diastases or starches of the leaven, the starch of the flour is hydrated and is in part liquefied in being transformed into dextrin.

When, about the temperature of 18° to 20°, the bread fermentation has arrived at its height, the dough is divided by the baker into lumps or pastes, which are taken to the oven. These cakes still increase in volume owing to the development of the gas included in the mass and to the volatilization of the alcohol which has been formed. At the same time the starch is hydrated by cooking and partly transformed into amylodextrin. The surface of the loaf becomes reddish in arriving at a temperature of 220° to 250°, and the bread comes out of the oven made up of a golden crust and a white and porous crumb, the temperature of which during cooking has not reached even to 100°. This temperature is however nearly always sufficient to destroy all the organisms of the dough and leaven.

We have here only to recall the manufacture of bread in its essential practices, without enlarging on the complicated art of bread making. It is sufficient for us to briefly point out the principles of it, and especially to study its product.

According to the best authors (Rivot, Poggiale, J. Koenig, Wanklyn, etc.), bread made and cooked to a nicety, should have the following approximate composition :—

Solid materials	66
Water	34 [2]
	100

[1] It is a curious fact that formerly Guy Paton (1668) and various members of the University of Paris were strong adversaries of yeast as also of potatoes. But supported by Perrault and other physicians, its use in the end prevailed by a decree of Parliament, March 21, 1770. However, the practice of using yeast as leaven, has remained for a long time reserved for best quality bread.

[2] Rivot gives for properly baked bread : Water, 30 to 33 per cent. ; Wanklyn and Cooper, 34 per cent. ; Ch. Girard, 33 to 34 per cent. The

Since 100 parts of flour[1] contain on an average 84 parts of solid substances and 16 parts of water, it follows that 100 kgs. of this flour ought to produce 129 to 130 kgs. of correctly baked bread.

Amongst bakers, those who aim at fraudulently increasing their profits arrange that 100 kgs. of flour shall produce not 130 kgs. of bread with 34 to 35 per cent. of water, but 140 to 162 kgs. with 34 to 40 per cent. of water. It is easy to obtain this result, either by adding to the flour of wheat a little flour of rice or maize, lime water and different salts which maintain a degree of hydration higher than in the case of starch (these frauds are rather rare); or preferably by overheating the oven before putting the bread in it, in such a way as to seize the surface of the paste which is then cooked for a shorter time and which keeps under its crust a quantity of superabundant humidity. This fraud is to be feared especially in the case of the large household breads consumed by the workman, who thus loses, on an average, 10lb. of bread per 100 kgs[2].

Good bread[3] ought to be light, resounding and well raised. It should give a minimum of 22 per cent. of a golden crust[4], brittle and difficult to detach from the crumb. The latter ought to be elastic and to have large cavities in it; if, after the bread is cool, it is moderately compressed between the thumb and index finger, the crumb should not stick together, but should slowly return to its original volume; it should not cling to the fingers which knead it. Good bread should absorb a great deal of liquid

customs and laws fix the amount of water at 34 to 35 per cent. In France, the process of military bread-making produces 146 kgs. of bread at 38 per cent. of water. This bread, it will be understood, is too aqueous and would not keep well. The analyses made by Poggiale of ammunition bread (about 1860) give only 34·17 per cent. of water in the bread of the French soldier; with 4·45 of starch, 4·1 of sugar and dextrin, 9 of nitrogenous matters and 6·1 of bran. (See *Rev. de médecine militaire*, 2nd series, t. XII, p. 351.)

[1] A mixture such as is employed in good bread making contains one-half to two-thirds of the flour of tender wheat and one-half to one-third of the flour of hard wheat.

[2] If the humidity of bread is of 41 per cent. instead of 35.

[3] *A priori* we can say that there is no *good bread* in the hygienic sense, except that which is made mechanically. Hand-made bread has received not only the sweat and often the products of the cough of the bread maker, but also his epidermic scales and everything that these may carry with them in cases of skin diseases when due regard is not paid to cleanliness, etc. In the better hand-made breads we sometimes find parts that have a sickly taste which are of human origin, or which come from insects and maggots in the flour.

[4] Barral: Average of twenty-five analyses of Parisian bread: 23 per cent. Average of fancy breads, 41·6 of crust. Rivot: Proportion of crust, minimum 22·5, maximum 44·7. Payen: English bread, average of six analyses, 24·4.

without being dissolved when it is *moistened.* It ought not to rub away under the fingers. The colour of the crumb ought to be very clear yellowish white and slightly translucid; its sweet odour of wheat should recall neither sourness, mouldiness nor fermentation. Dried in the oven without being baked, good wheat bread should not lose more than 36 per cent. of its weight. Cut in slices 1 centimetre thick and left in the air, good bread in drying ought not to diminish by more than 25 per cent. even after a fortnight.

Bread which is too watery is heavy and only slightly sonorous; its sticky crumb, when rolled between the fingers, leaves a visible oily mark. The crust of this bread weighs less than one-sixth of the total weight.

In Paris for some time past, the only flours employed in bread making have been bolted to 28 per cent. at least, that is to say, from the raw product of the grinding of the grain, 28 parts have been thrown out in the form of bran. These flours have the advantage of giving a very white bread, but less rich in gluten and less savoury than bread made from flours bolted to 22 per cent. only. These latter give a bread a little less white, it is true, less leavened but more savoury, richer in organic phosphorus and gluten and more nutritive. In following this practice of exaggerated bolting, a practice at the most good for a rich man who finds nitrogenous aliments in superabundance in his daily nourishment, reality is sacrificed for appearance and the workman deprived of a more nutritive bread for which he would have to pay less.

Bread which is just cool when it comes out of the oven is called *soft or fresh bread.* Its crumb retains for some hours the aptitude of consolidating under a sufficient pressure or by mastication. After twelve or fifteen hours the bread becomes *stale.* It crumbles then under the fingers and its taste is less delicate. But stale bread is easier to digest because it is more pervious to the digestive juices. This change in bread is not due to dessication; it takes place even in surroundings saturated with moisture. Besides, in becoming stale, bread only loses 2 per cent., and even less, of its water. The change of fresh bread into stale bread is due, as M. Lindet has shown, to the fact that a part of the starch which was transformed into amylodextrin (it forms about 10 per cent. of the weight of the bread when it comes out of the oven), returns at the end of twelve to twenty-four hours to the state of starch. The amylo-dextrin reappears in small proportions and for some hours only, when the stale bread is again put into the oven, which then again takes on some of the characteristics of new bread.

The starch of fresh bread, which absorbs from four to five times its own volume of water, will not absorb more than twice its own

volume when the bread is stale. The latter therefore, swells less in the stomach.

Here are some analyses of the usual wheat breads :—

Average Percentage Analyses of White Wheat Bread.

	Rivot.	J. Koenig.	Wanklyn and Cooper.
Water . . .	43–33·2	33·59	34·00
Starch . . .	35–44·5 }	51·78 }	54·50 }
Dextrins . . .	9– 3·9 }		
Sugars . . .	2– 1·3	4·02	
Fats	1– 0·7	0·46	—
Proteid matters	9·3– 8·8	7·06	9·50
Mineral matters	0·7– 1·3	1·09	2·0

Barral has given the following analyses of the *whole loaf*, of the *crust* and of the *crumb*, of a same loaf of Paris, weighing 4 lbs. (known as Mason's loaf) :—

	Whole Bread.	Crust.	Crumb.[1]
Water	38·30	17·15	44·45
Insoluble nitrogenous matters .	6·24	7·50	5·92
Soluble ,, ,, .	1·86	5·70	0·75
Soluble non-nitrogenous ,, .	4·04	4·88	3·79
Starch	47·84	62·58	45·55
Fats	0·81	1·18	0·70
Mineral matters	0·91	1·21	0·84
	100·00	100·00	100·00

100 parts of good fresh wheat bread give, according to Rivot, 0·6 to 0·8 grms. of ash. This ash has the following composition per gramme :—

Alkaline bases	0·211–0·272
Lime	0·111–0·144
Oxide of iron	0·043–0·051
Cl (expressed in HCl)	0·065–0·039
SO^3	0·010–0·007
P^2O^5	0·500–0·438
CO^2	— –0·003
Silica	0·016–0·019
Sand and clay	0·040–0·021

The alkaline and earthy phosphates form the greater part, as we see, of this ash, but a notable portion of the phosphoric acid derives from the oxidation of the phosphorus of the lecithins,

[1] Crust 22·5 ; crumb, 77·5 per cent. of bread.

nucleins, methylenephosphoric acid, etc., which have disappeared. In fact, to saturate in the state of bibasic phosphate the alkaline and alkaline earthy bases contained in the ash of 100 parts of bread, 0·232 grms. of P^2O^5 will suffice; but we find on an average 0·470 grms. The difference, say 0·238 grms., is due in a great measure to the combustion of organic phosphorus. In traversing the system the phosphorated compounds of the bread eaten, are oxidized in the same way and pass to the state of phosphoric acid. It follows from these remarks that *bread like meat tends to acidify the blood*, an important observation to which we shall often return and which shows the necessity of the addition of vegetables to alimentation.

The crust of bread is more nourishing than the crumb; it is more soluble in water and richer in nitrogenous matters in the proportion of one to two. It is also more easily digested and more exciting to the stomach.

Toast and water, bread soup and rusks, can be quoted amongst aliments which are more favourable to the development of nurslings and convalescents.

In large towns, breads for both rich and poor have been manufactured from all time—fancy breads, first and second quality bread, plain bread, brown bread, black bread, etc. But here, especially, we must not judge things by appearance without examination. In Paris, the breads spoken of as *fancy* breads, are those which *have not the weight* (it often falls short by more than one-third). Made from a flour which has been too much bolted, they are richer in starch and poorer in gluten than the bread spoken of as of the second quality. They are then better to look at but less nourishing. On the other hand they are cooked to a nicety, and often only contain 28 to 30 per cent. of water.

On the contrary, in the country, the bread is coarser to look at, either owing to the addition of a certain proportion of rye flour, about an eighth, to prevent it drying and to give it more flavour (as in the case of *ammunition bread* of the soldiers), or because a part of the bran is left in it, or again because it is bolted to 15 or 16 per cent. only, which causes the flour to contain the epispermic cells of the grain with their special ferment *cerealine* of Mège-Mouriez[1] suitable for browning the bread during its manufacture. But this greyish bread, or brown bread, is more nutritive, savoury, richer in gluten, nitrogen and phosphorus than white bread. Magendie whilst studying bread from this point of view, noticed that a dog nourished solely with the best white bread, died at the end of 50 days, whereas another dog,

[1] *C. rend. Acad. sciences*, t. XXXVII, p. 427; t. XXXVIII, p. 505; t. XLVI, p. 126; t. XLVIII, p. 431; t. LXI, p. 1,137.

exactly similar, exclusively nourished on brown bread (flour and bran) lived indefinitely[1].

The ancients ate only brown bread, and the people who in Europe hold to this custom are very healthy. Hence the recommendation to use once or twice a week bread called *complete*, that is to say, bread containing a part of its bran; or even of *bran bread* which contains all bran.[2]

Brown bread, especially when mixed with a little rye, is more nutritious and refreshing than white bread. It must be added that, because of the intestinal peristalsis which it increases, brown bread is less used than white and gives more abundant excrements. Thus, after the ingestion of a pound of white bread, about 5 per cent. of the weight of its substances, calculated dry, corresponding to 20 per cent. of the total nitrogen and to 1 per cent. of carbo-hydrates, remain in the fæces. Rye bread leaves in the excrements 10 to 15 per cent. of its weight calculated dry and 20 to 30 per cent. of its nitrogen. The bread spoken of as *complete*, that is to say without the separation of any bran, is still more imperfectly absorbed.

The following analyses, due to M. Balland, whose competence in matters relating to alimentation is well known, show the superiority in nitrogenous nutritive materials of farm bread and French ammunition bread over the white bread of Paris and especially over the extra-white bread called *fancy bread*. We add to it, according to the same author, the composition of bread used in French warfare and of the biscuits used by the troops :—

COMPARATIVE PERCENTAGE COMPOSITION OF VARIOUS SORTS OF BREAD AND BISCUITS.

	Farm Bread (Bresse).	Ammunition Bread.	Fancy Bread (Paris).	Bread in time of War (Paris).	Biscuit of the Forces (1894).
Water	32·60	38·50	31·60	11·40	11·30
Nitrogenous matters	7·25	7·98	5·99	10·50	13·20
Fatty matters	0·40	0·15	0·24	0·60	0·42
Starch and sugar	59·04	52·13	61·59	72·66	73·75
Cellulose	0·14	0·28	0·14	0·34	0·44
Ash	0·57	0·97	0·44	1·04	0·89

Flour ground by a cylinder and not by a millstone, flattens the grain before crushing it and causes a part of the gluten to pass into the bran. Here are some analyses of white bread according to M. Muntz; the first has been made with flour crushed by a cylinder (yield 70 of flour per 100 of grain), the second with flour crushed by the millstone (yield 70 per cent.).

[1] *Compt. rend.* t. XXVIII, p. 40.

[2] Using bran bread once or twice a week is not equivalent, we must understand, to eating brown bread each day.

	White Bread made from Flour crushed by a Cylinder.		White Bread made from Flour crushed by a Millstone.	
	Crust.	Crumb.	Crust.	Crumb.
Water	20·7	41·4	21·5	37·8
Nitrogenous matters . .	8·06	5·87	8·50	6·62
Fatty matters	0·08	0·02	0·19	0·10
Matters soluble in alcohol	0·32	0·30	0·60	0·43
Sugars	0·18	0·14	0·29	0·20
Mineral matters . . .	·981	1·57	2·52	2·06
Phosphoric acid . . .	0·19	0·13	0·28	0·20

It is seen that the yield by the millstone is greater, and the weight of albuminoid matters higher.

The exaggerated bolting of flours, since the departure made by the *Hungarian grinding* or cylinder grinding, in substituting for ordinary bread one which is whiter but less nutritive, less phosphorated and less nitrogenous, is certainly one of the causes of the impairment of the general health of Europe.

The processes studied by Mège-Mouriez for eliminating the creatin or restraining its action on the flour which it darkens during the making of the bread, have enabled them to make for some time past in the factories which produce the bread for our hospitals, a bread almost as white as fancy bread, also quite as agreeable to the taste and much more nutritive.

Harmful Substances.—Adulterations of bread. Bread made with sour yeast possesses a disagreeable acidulated flavour. It is the same if the yeast has been employed in an exaggerated proportion, usually with the object of using and raising flours of inferior quality. The bread may also have, in this last case, a slightly bitter taste.

If it is made with damaged flours or is too aqueous and badly cooked, it is liable to be invaded (especially in the warm time of the year), either on the surface or in the interior, by different fungi : *Oidium auruntiacum* which covers it with a pale yellow efflorescence ; *Ascophora nigricans* which darkens it in the interior and makes the bread poisonous ; *Aspergillus glaucus* and *A. flavus*, *Penicilium glaucum* rapidly invade it with their moulds. All these mouldy breads cause diarrhoea and sometimes serious poisoning. Their taste, like their alimentary value, is changed.

The brown rust of wheat (*Tilletia caries*), blight (*Pucinia graminis*), rye grass, and mildew of the fields also communicate to the flour and bread some harmful properties.

Finally, flours badly kept or too old are liable to be invaded by certain insects : the fleshworm or *Tyroglyfus siro farinae*,

the flourworm, etc., which leave in the bread after it is cooked their nauseous detritus.

The principal adulteration of bread consists in its exaggerated hydration: we have spoken of this previously (p. 223). A bread containing more than 37 to 38 per cent. of water should be considered as adulterated. This adulteration cannot be watched too carefully, as it especially affects the poor to the advantage of the manufacturers who draw an excessive interest on their capital.

Sulphate of copper, in doses of .1 grm. per 35 kgs. of flour enables the quantity of water in the bread to be increased and a crust and crumb satisfactory to the eye to be obtained even with questionable flours. Alum and borax serve also to give some whiteness to breads made from flours bolted to a small degree.

Finally, the addition to bread of flour of rice, black wheat, leguminosae of fecula, constitutes a fraud easy to recognize under the microscope, by the examination of the grains of starch.

Various Derivatives of Bread.—The nutritive power of bread can be increased by the addition of gluten powder or preparations of dry casein.

We can also add to the flour milk, eggs and butter forming some savoury and very nutritive preparations from which cakes, biscuits, strips of paste, macaroni, etc., are made. With the addition of cheese the latter constitute the rational, very nutritive and cheap food of the poor Italian populations.

Gingerbread is made with the flour of wheat, with rye and the addition of honey, molasses, aniseed, cloves, cinnamon and from 1 to 1·5 per 1,000 of potassium carbonate. It is a rather agreeable aliment, very slightly laxative. One can, by various additions, make a medicated bread of it.

Gluten bread, for diabetics, is prepared by drying gluten at 100°, finally pulverizing and kneading it with a little flour, water and butter or more often by adding powdered gluten to ordinary flour and finally converting it into bread. The bread called *gluten* may contain from 5 to 8 per cent. and sometimes as much as 25 per cent. and more of starch. It has been attempted to replace it by soja bread, very rich in gluten, more nutritive than ordinary bread, but of a not very agreeable taste. Bread is also made of the flour of wheat with the addition of a large proportion of flour of sweet almonds.

There have been made or proposed to be made for the army some very nitrogenous breads, made with flour of wheat previously raised to 140°, then kneaded with the flour of leguminosae and finally cooked in a baker's oven. These preparations, mixed with water and boiled, produce an aliment rather agreeable to taste and very nutritive.

The composition of biscuits, brioches, croquets, wafers, etc.,

which are often given to invalids and children, deserve to be stated here. I reproduce M. Balland's analysis :—

	Biscuits in Tin.	Dessert Biscuits.	Brioche.	Bordeaux Croquet.	English Wafers.	Ginger-bread.
Water	9·20	14·00	21·10	1·00	5·70	14·60
Nitrogenous matters	7·70	9·82	9·40	10·50	8·40	3·74
Fatty „	2·60	6·35	22·85	12·15	1·15	1·15
Sugary „	42·80	59·86	4·50	43·17	44·38	28·90
Starchy „	37·40	8·62	40·46	31·83	39·97	48·86
Cellulose	0·10	0·35	0·35	0·85	—	0·81
Ash	0·20	1·00	1·34	0·50	0·40	1·94
	100·00	100·00	100·00	100·00	100·00	100·00

All these preparations are made with flour, butter, sugar, yolk of egg, milk, sometimes almond paste, white of egg, etc., and are differently sweetened and flavoured.

XXI

SEED VEGETABLES—SHOOTS, BULBS, TUBERCLES AND ROOTS

BREAD and meat suffice to nourish man, but they cannot maintain him indefinitely in health. They both, as has been seen, have a tendency to acidify the blood. Should vegetables be wanting at any time, the humours will become less and less alkaline and symptoms of a scorbutic nature will appear. It is not only the use of salt meats which causes these ; scurvy in Paris, during the siege of 1870–71 attacked a population which had not been fed on salt meats but had wanted vegetables.

They not only carry to the system a large proportion of alkaline and alkalino-terreous bases (potash, soda, lime, magnesia), but especially some alkaline salts with organic acids, suitable, by oxidation of the combustible part of their molecule, to transform themselves into carbonates in the tissues and plasmas where they saturate the phosphoric and uric acids, etc., originating the destruction of the nucleo-proteids, as well as the sulphuric acid which arises from the incessant oxidation of the sulphur of the albuminoids. Whilst the ash left by the combustion of wheat flour, rye, or of bread is formed of acid phosphates as we have seen, the combustion of peas, beans, haricots, cabbages, etc., leaves, on the contrary, purely alkaline ash. This excess of alkali in the products of combustion of vegetables over the quantity which would suffice to neutralize the strong acids which are found there (phosphoric, sulphuric, etc.), arises from the destruction by fire of the salts with organic acids of these vegetable aliments. But we know, according to Woehler, that in the animal system, the alkaline tartrates, citrates, malates, etc. (which are absorbed by the mouth or given by injections), pass, in consequence of the successive oxidations which they undergo in the tissues, into the state of carbonates of potash or soda which alkalize the blood and urine. If the analyses of the ash of beans or haricots are calculated, one finds for 100 parts, in the beans twenty parts, in haricots seventeen parts of potash in excess of the quantity which is able to saturate the whole of the strong acids present. 100 grammes of beans in the natural state (dried in the air) have given me on combustion, 3·93 grms.

of salts of which 2·34 grms. of soluble salts alkaline to phenolphthalein which correspond to 0·184 grms. of free soda.

Dry vegetables then are an indirect source of alkalis. *A fortiori* it is thus with herbaceous vegetables. These are, in the case of the herbivorous animal, the large providers of bases and of mineral matters. For 100 parts of substances, calculated dry, cos lettuce brings from thirteen to twenty-two parts of mineral matters ; spinach and celery from sixteen to twenty ; cabbage from twelve to ten ; Brussels-sprouts ten ; cauliflower nine ; turnip eight parts of mineral salts. *All these ashes are strongly alkaline.*

It is the same with fruits : the most acid, such as apples, pears, peaches, cherries, gooseberries, strawberries, grapes, tomatoes, etc., also contain a large quantity of alkalies in the state of organic acid salts, which contribute, while becoming oxidized in the system, to alkalize the blood and the humours.

Vegetables and fruits fulfil still another office. They regulate the stools in exciting by their cellulosic residues the intestinal peristalsis. Owing to them, the fæcal matters form a sufficiently coherent mass, which does not wound the intestine by its hardness and which can be easily expelled.

We have seen (Part I.) that according to Rübner, Woroschiloff, Atwater, etc., vegetables with equal weights of nutritive principles have not such a high alimentary value as meat, which is more favourable to the development of muscular force. Herbaceous foods tend to increase the hydration of the organs and to raise the absolute weight of the body, whilst diminishing its density.

A good proportion of fresh vegetables in the food, about 250 to 300 grms. a day, is the average quantity which may be considered as sufficient and necessary.

In order to study these aliments, we shall divide them into seed vegetables, young shoots and buds, tubercles and roots.

Seed Vegetables.

The vegetables which we sometimes call *dry vegetables*, are peas, dwarf peas, haricots, beans, lentils, etc.

Of all the nutritive materials, including meat, seed vegetables constitute the aliment most rich in albuminoid principles and ternary substances. These are then very nourishing products and one may say complete aliments.

Rübner has been able to maintain the nitrogenous and carbonated equilibrium of his subjects under experiments solely with 520 grms. per day of dry peas given in pap. The digestibility of seed vegetables is, it is true, a little weaker than that of meat and of bread and the assimilability of their principles a little more difficult, but the value they possess by their richness in nitrogenous, starchy and phosphorated principles should make

them enter more largely into our daily food. That is what the Germans have very well understood in adopting for the army their *sausage and vegetable tablets* and I have been able to effect a like result in making the Technical Committees of the Minister of War since 1888 agree that these dry vegetables should enter into the food of the soldier and reserves of the entrenched camps. I add that peas, haricots and especially lentils, keep a long time—a year or more—without sensibly modifying their intrinsic constitution. They are very little subject to the attack of insects ; they can besides, if necessary, be dried and sterilized. These are valuable practical properties.

The proteid matters of seed vegetables are especially formed of legumin, a kind of vegetable casein easily digested.[1] It corresponds, according to Ritthausen, to the composition $C = 51{\cdot}48$; $H = 7{\cdot}0$; $N = 16{\cdot}7$ (peas, lentils) to $14{\cdot}7$ (haricots) ; $S = 0{\cdot}40$ to $0{\cdot}45$; $O = 24{\cdot}3$ (peas, beans) to $26{\cdot}3$ (haricots). Legumin forms with the alkalies some soluble salts ; but with lime or magnesia it produces insoluble combinations which explains the hardening of these aliments when they are cooked in very chalky water. In this case, it is well to correct this by adding beforehand a little carbonate of soda (0·3 grms. to 0·5 grms. per litre of water) which precipitates the alkaline-earthy salts.

The legumin is always accompanied in the seed vegetables by the oxymethylenediphosphates (see p. 210) and by the phosphorated nucleins so much the more abundant as these vegetable products are eaten in the state of seeds more imperfectly developed, or tender shoots, or buds, etc.

Cooking, while hydrating the starch of seed vegetables and partly transforming it into amylodextrin, renders these foods more digestible and at the same time increases the weight of the material which is hydrated. Puree of peas contains 70 per cent. and more of water, whilst green peas only contain 14 per cent. at the most. This is partly the reason of the feeling of satiety which these purees occasion.

On the other hand, after cooking, the cellulose, of which a certain proportion always exists in every vegetable, can be absorbed in the intestine to the extent of a half and sometimes more (Kniriem).

As for the chlorophyll or colouring matter of green vegetables, it does not appear to have any nutritive value whatever.[2]

[1] See note, p. 215, its relations with edestin.

[2] In order to preserve in green vegetables the colour which is pleasing to the consumer, many manufacturers in France, England and America add, during the cooking and packing of the preserves, a small quantity of salts of copper. The analyses of preserves thus prepared have given 0·016 grms. to 0·050 grms. of copper per kg. of drained vegetables (A. Gautier, *Annales Hygiène*, etc., Paris, 1876, 3rd series, t. I, p. 5). These

Mineral matters which by the green or herbaceous vegetables play in alimentation such an important part, vary very much with the soil in which these vegetables have grown. The following table gives the quantity which 100 parts of fresh vegetables furnish of it, and at the same time the percentage composition of these matters :—

COMPOSITION OF ASH LEFT BY SEED VEGETABLES.

	Lentils.		White Haricots	Worms Haricots.	Dutch Peas.	Alsace Peas.	Beans.
Ash for 100 fresh parts	2·32		3·29	—	2·88	—	1·66
For 100 parts of ash :							
K^2O	27·84	34·76	39·51	38·89	34·19	36·31	20·82
Na^2O	8·76	13·50	3·98	11·78	12·86	1·76	18·10
CaO	5·07	6·34	5·71	5·90	2·46	10·39	7·26
MgO	1·90	2·47	6·43	9·03	8·60	12·24	8·87
NaCl	5·18	4·63	3·71	0·55	0·52	1·90	2·44
Fe^2O^3	1·61	2·60	1·05	0·11	0·96	—	1·03
P^2O^5	29·07	36·30	34·50	31·34	34·57	31·00	37·94
SO^3	15·83 [1]		4·91	2·49	3·56	4·84	1·34
SiO^2	1·07		—	0·44	0·29	1·54	2·46
Authors	Lévy		Boussingault	Lévy	Thou	Boussingault	Bichon

These numbers at once show the enormous proportion of alkaline phosphates contained in the ash ; the excess of alkalies over the phosphoric acid and the other radicals, the remarkable richness of some vegetables (haricots, peas, beans) in magnesia, a base which almost always accompanies organic phosphorus and sulphur. Phosphoric acid coming from the organic phosphorus of the lecithins, nucleins, etc., rises for 100 grms. of green peas to 0·240 grms. and for 100 grms. of haricots to 0·187 grms. with 2·7 and 3·1 grms. of total ash. We see also that the proportion of iron in lentils, beans, haricots, etc., is considerable. It is in the rich vegetable matters which ether dissolves that the lecithins are found.

Here is the most indispensable information concerning each of these foods in particular.

Haricots.—There exist many varieties. I give here the analysis of some according to M. Balland [2] :—

quantities of copper slightly change the flavour of the vegetables but do not appear to act susceptibly on the health of the consumer. It would, however, be as well if this practice were to be discontinued.

[1] This number corresponds in this particular case to that of the carbonic acid of the carbonates of the ash and not to that of SO^3.

[2] *Compt. Rendus*, t. CXXV, p. 120.

For 100 parts.	Seeds of White or Red Haricots.		French Beans in full Pods.
	Minimum.	Maximum.	
Water	10·00	20·40	92·00
Nitrogenous matter	13·81	25·16	1·90
Fatty matter . .	0·98	2·46	0·28
Sugar and starch .	52·91	60·98	4·17
Cellulose . . .	2·46	4·62	0·74
Ash	2·38	4·20	0·82

The maximum of fatty matters and the minimum of nitrogenous matters are only exceptionally met with and in the very large haricots of Spanish origin. The ash of these fats contains a large proportion of manganese. The digestion of haricots is only difficult for tired and weakened intestines. It is nevertheless not accomplished without the production of gas. It is a healthy and very nutritive food, especially for those in good health. French beans are contra-indicated in cases of arthritis.

Peas.—The different varieties of peas (white peas of France and Germany, green peas of the East, of the North, of Noyon, Holland, etc.) have such a uniform composition that they more closely resemble haricots and lentils. Here it is according to the same author (*loc. cit.*). It concerns dry and not green peas :—

	Minimum.	Maximum.
Water	10·60	14·20
Nitrogenous matter . .	18·88	23·48
Fatty matter	1·22	1·40
Sugar and starch . . .	56·21	61·10
Cellulose	2·90	5·52
Ash	2·26	3·50

The small green peas, not entirely formed, are richer than the large ones in nitrogenous matters (Poggiale). For the small green peas in seed, M. Balland has found : Water, 78·8 ; nitrogenous matter, 4·47 ; fatty matter, 0·24 ; extractives, 14·02 ; cellulose, 1·65 ; ash, 0·72 per cent.

Pea soups and purees are easily assimilable but relatively small in nourishment. Pea puree contains up to 70 and 80 per cent. of water.

The split peas of commerce are more nourishing than the ordinary dried peas.

We eat the husk of green haricots not yet developed in their pod and that of peas called "*mangetout*"[1] while it is full of

[1] *Mangetout.* A kind of haricot bean of which the French eat both pod and seed.

starchy and albuminous juices intended to nourish the scarcely formed seeds. These are aliments rich in sugar, assimilable cellulose, inosit and nucleins.

Lentils.—Their composition shows some sort of analogy with that of beans but they are less rich in cellulose. The small lentils of Egypt, of the South of France and of Auvergne are more savoury and more nitrogenous than those of Paris, Bohemia and Russia, the seed of which is at least twice as large. Here are some analyses of this vegetable before cooking: they relate to 100 parts (the same author; *loc. cit.*):—

	Minimum.	Maximum.
Water	11·70	13·50
Nitrogenous matter	20·32	24·24
Fatty Matter	0·58	1·45
Sugar and starch	56·07	62·45
Cellulose	2·96	3·56
Ash	1·99	2·66

Beans.—Beans from different countries (Artois, Burgundy, South of France, Egypt, Algeria, Koenigsberg etc.) differ somewhat amongst themselves in look and size, but their composition, at least that of the kernel deprived of the episperm, varies little.

The bean is a very nutritive and nitrogenous aliment. Pliny relates that the people of Northern Italy used it in all their foods. The use of the bean deserves to be more general. Deprived of its outer covering, its seed forms an excellent vegetable, savoury and very nutritive. The low price of this aliment and its richness in legumin point very naturally to its being a food for the poor. A given weight of bean nourishes more than the same weight of meat.

Here are, according to M. Balland (*loc. cit.*) some analyses—maximum and minimum—of the bean, kernel and skin included, for 100 parts:—

PERCENTAGE COMPOSITION OF EDIBLE BEAN.

	Minimum.	Maximum	Whole Bean from the South.	Kernel. 83·2%	Envelope 15·1%.
Water	10·60	15·30	11·10	10·90	9·80
Nitrogenous matter	20·87	26·51	22·95	26·98	3·44
Fatty matter	0·80	1·50	0·92	1·12	0·25
Starch, sugar, etc.	50·89	58·03	54·11	56·74	34·56[1]
Cellulose	5·24	7·86	7·68	1·16	49·70
Ash	2·06	3·26	3·24	3·10	2·25
			100·00	100·00	100·00

[1] 34·56 of *extractive matter* from which *starch* is entirely absent.

The small Egyptian beans, brown or black in colour and round in form, are the most nitrogenous (nitrogenous matters, 26·51 per cent.); after them, in decreasing order, come those of Bresse, Lorraine, Koenigsberg and Artois. The least nitrogenous are those of Algeria and Tunis.

Peas or beans of Soja.—This is the oily pea of China and Japan where its cultivation dates from the earliest times. Its feeble quantity of starch and its richness in albuminoids has given rise to a proposal to make bread of it for diabetics. Here is according to M. Balland the composition of this interesting seed[1]:—

	Maximum.	Minimum.
Water	11·30	10·00
Fatty matter	14·80	12·95
Proteid ,, ...	38·41	34·85
Starch, dextrin, sugar .	32·11	26·74
Cellulose	6·20	3·60
Mineral matters . . .	5·20	4·35

Its ash is chiefly composed of phosphates of potash and magnesia, with a little calcium sulphate.

One will notice the exceptional richness of this aliment in nitrogenous principles. Starch rises on an average in this flour to 28 per cent. instead of 45 per cent. in that of wheat. Unfortunately the taste of this vegetable is not very agreeable.

In Japan the flour of Soja is mixed with cooked rice and left to ferment, and a sort of broth or sauce is thus obtained which takes the place of extract of meat.

Powders of Comestible Flours of Leguminosæ and Gramineæ.

The richness of the seeds of leguminosæ and gramineæ in nitrogenous and phosphorated nutritive materials has given rise to a great number of specialities of flour and powders which, boiled in water or mixed with milk, broth or eggs form some very nourishing soups and purees. These powders are nearly all mixtures of the flour of grains of leguminosæ with that of cereals (barley, maize, oats, etc.) in suitable proportions. These preparations usually undergo a slight torrefaction which sterilizes them and communicates a slight perfume to them and also partly transforms into more assimilable materials some of their nutritive principles. Thus the starch in them is partially changed into amylo-dextrin and very digestible dextrins. Finally the seeds

[1] *Compt. Rendus*, t. XC, p. 1177 and t. CXXXVI, p. 936.

destined to make these semi-medicamental preparations, are submitted to a commencement of germination which partly peptonizes their proteid principles and partly makes their starch soluble. The gemmules are then cleared away by means of appropriate mills and the grain from which the germ has been removed is transformed into flour. These are the flours called *diastased*. They are prepared with corn, wheat, oats, maize, etc., with the addition or not of leguminosæ.[1]

We mix these flours among themselves in proportions which vary according to each brand. One of these which is the most in vogue, through being largely advertized, appears to be made with a mixture of diastased flours of peas, haricots, lentils, oats, maize and cocoa. Sometimes the yolk of egg is added and worked up with these powders, afterwards being dried and pulverized afresh. Finally, they can also be made with the addition of milk, powdered milk, phosphates, etc. Good preparations are obtained by submitting to a slight heat a part of the diastased and degerminated grain, then adding the other part which brings its diastases intact and active.

Heated with water these different preparations give very nutritive soups. They agree with children from the seventh to the eighth month. Before that age they are ill-supported, the starchy and leguminous matters which they contain being difficult for young stomachs to digest. They are, on the contrary, good foods during the second year. They may also be prescribed for convalescents, except in the case of dyspeptics, the microbic fermentation of their sugars and dextrins in the stomach being very rapid, and capable of even preceding the hydrochloric secretion.

Conserves of Vegetables, with or without Meat.

Dried, compressed, powdered or shredded vegetables, with or without fat, with or without meat, render great service in the diet of soldiers, sailors and travellers. It will be useful to make here a few observations concerning them.[2]

Dried Vegetables and Vegetable Soups.—Different vegetables (cabbages, carrots, potatoes, French beans, turnips, etc.) are chopped up by a machine into thin slices, dried in the oven so long as they contain more than 13 to 14 per cent. of water. They are then compressed into a mass whose density equals 1.

Soaked in water, these preparations keep for quite a long time,

[1] J. B. Boussingault relates in his *Memoirs* (t. IV.) that at Chocco he has seen the Indians also feed themselves with flour made from grains of maize, slightly germinated, then heated, flour which they swallow after having simply mixed it with river water.

[2] We owe the following details chiefly to the works of M. Balland (*Mémoire des Annales d'hygiène et de méd. légale.* August 1901 in particular).

swell a little, can be cooked and have the convenience of always being ready for use as a normal indispensable complement to meat foods. These preserved vegetables are of the greatest service to sailors, explorers, soldiers, etc.

The conserves of French beans, green peas, etc., are to be got by first bleaching these vegetables by boiling for an instant in salt water, then pouring them into tin boxes with a certain proportion of prepared liquid (water, salt, spices, etc.) then sealing and carrying to the autoclave at about 115°.

Here are some analyses according to M. Balland of vegetable soups, cabbages, dessicated haricots, etc., destined for the army.

	Julienne of French origin.	White Cabbages in Dried Cakes.	French Beans dried.	Green Peas in Tins (drained).
Water	13·80	18·00	10·60	77·00 [1]
Nitrogenous matter	7·75	8·12	17·80	5·36
Fatty matters	1·50	0·30	1·15	0·46
Starchy matter and extractives	67·33	63·13	57·10	13·96
Cellulose	5·16	7·75	8·65	2·30
Ash	4·46	2·70	4·70	5·17

Conserves of Soups; Conserves of Meat and Vegetables.—In France attempts were made to prepare as food for the soldier while campaigning, complete dry conserves with peas, meat, fat and dried onions. They contained for 100 parts, 20 of pure cooked meats, 20 of fat, 48 of pea flour, 4 of onions, 8 of salt and pepper. This preparation had no success ; it quickly becomes rancid, takes a sharp and disagreeable flavour, etc.

After successive attempts the "*conserve de potage aux haricots*," made with 60 per cent. of flour of *peeled* haricots,[2] 30 of fat, salt and pepper was arrived at. The haricots should have been previously cooked and partly dried before being ground. This preparation is placed in tin boxes and sterilized at 115°. It looks like a homogeneous yellowish paste, and preserving its flavour for a long time without becoming at all rancid, it makes plentiful soups. The preserves of meat-vegetables for the army according to the Instructions published in the *Bulletin militaire* of February 6, 1901, contain for 100 parts : Flour of haricots cooked and dried before grinding, 54 ; fat, 25 ; lean pork meat, 15 ; pared onions, 1 ; salt, 5 ; pepper, 0·3 ; it seemed to be better appreciated by the soldiers than the preceding preserves.

[1] Green Peas cooked in water and not dried.

[2] All vegetables not peeled become disagreeably bitter in time.

CONSERVES OF VEGETABLES

The following are two analyses of these products :—

	Conserve of Soup with Haricots.	Conserve of Haricot Puree with Pork (mixed).
Water	6·40	12·90
Nitrogenous matter . .	13·55	18·85
Starchy ,, . .	24·20	26·98
Cellulose ,, . .	44·31	33·75
Ash	2·44	1·90
	9·10	5·62
	100·00	100·00

The conserves of soups used in the German army are mixtures of cooked flours of haricots, lentils and peas with fat and salt. They contain a little more nitrogen than those of the French army owing, it appears, to the addition of extract of meat. They are also, and rightly so, more spiced than the French.

They are transported in packets of flat round pieces wrapped in parchment paper ; each piece weighing 150 grms. when diluted with boiling water gives a thick soup. Here is the composition of a few of these preserved soups :—

	Conserve with Haricots.	Conserve with Lentils.	Conserve with Peas.
Water	9·10	8·90	8·00
Nitrogenous matter	16·14	17·97	17·50
Fatty ,,	22·10	20·60	19·05
Starchy ,,	41·98	38·83	42·45
Cellulose . . .	3·96	3·60	3·10
Ash	6·72	10·00	9·90
	100·00	100·00	100·00

The conserves for soups (*Cartouches-rations*) of the English army are very varied (fats, extracts of meats, powdered meats, haricots, potatoes, peas, rice). They seem to be little valued by the English soldier.

Eibrennsuppe of Austria-Hungary is in square packets, 36 grms. each, covered with parchment paper. They consist of flour of vegetables and wheat, of the pulp of potatoes, burnt onions, anise. . . .

The Belgian *conserves of soups* have also the flour of leguminosæ for their base, with the addition of fat, extract of meat, pepper, leek and salt. They are a little more nitrogenous and richer in cellulose than similar French makes.

The tablets of *viande-legumin* are prepared with 1 part of meat powder and 6 parts of flour of peas, beans, lentils. They contain 12 per cent. of water ; 28·7 per cent. of albuminoids ; 2·2 of fats ; 50 of carbo-hydrates ; 3 of salt.

The greater part of these aliments, and other similar products, keep well in a dry place but they have the property of becoming rancid when they remain exposed to the air for some time.

Shoots, Bulbs, Tubercles and Roots.—In this class we shall place: Vegetables eaten in the state of *buds* or of young shoots, such as asparagus, artichoke, cabbage, etc.; secondly *tubercles*, underground appendages of the stalk such as potatoes, Jerusalem artichoke, sweet potatoes, yams, colocasia, etc.; thirdly *bulbs*, onion, leek, garlic; fourthly *roots*, carrot, turnip, salsify, viper's grass, etc.

Shoots, Buds.—*Asparagus* which is eaten in the spring is constituted by the young stalk, or shoot, of the plant which is gathered just at the moment when it is leaving the earth. It is a highly esteemed dish containing nucleo-proteids, mannite, asparagine $C^4H^8N^2O^3$, aspartic or amidosuccinic acid $C^4H^7NO^4$ and a substance which, in traversing the system, communicates to the urine a very disagreeable special odour.

Here is the analysis of white rose asparagus which I again borrow from M. Balland :—

	Heads cut at 0·05 m. from the top.	Length of 0·05m. cut below these Heads.
Water	90·50	92·80
Nitrogenous matter	1·31	0·67
Fatty bodies	0·31	0·11
Starch and mucilages	6·78	5·40
Cellulose	0·69	0·65
Ash	0·41	0·37
	100·00	100·00

The *artichoke* is formed by the unexpanded heads of the *Cynara scolymus* of the family of the Synantheræ. The lower part of the scales and the receptacle which carries them, are rich in inulin and very nutritive nitrogenous albuminous matters.

Here is, according to M. Balland, the analysis of the receptacle (bottom of artichoke) and the edible white part of the central leaves of the artichoke.

	Receptacle.	Bottom of Leaf.
Water	80·80	80·90
Nitrogenous matter	3·68	3·76
Fatty „	0·21	0·52
Extractive „	13·07	12·73
Cellulose	1·27	1·53
Ash	0·97	0·56
	100·00	100·00

We find manganese in the ash.

The *cabbage* (*Brassica oleracea*, Cruciferæ) has been cultivated from time immemorial as an alimentary plant. It contains a great quantity of water (from 89 to 94 per cent.). After a long boiling, if it is a matter of the cabbage in leaf, the residue constitutes a common dish, but savoury and very nutritive, rich in nitrogenous and sulphurated albuminous principles, recalling a little as to taste beef tea and extract of meat.

There are a great number of edible varieties of this valuable vegetable: *green cabbage, savoy cabbage, headed cabbage, red cabbage, cauliflower, Brussels sprouts*, etc.

The ordinary green cabbage with large leaves and the headed cabbage are of great use in the alimentation of the masses. With bread and bacon they provide a healthy nourishment for strong stomachs, economical and very nutritious, of which one does not become satiated.

Cauliflower is formed by the budding branches of the stalk of the vegetable grouped in bunches still united amongst themselves. It produces a fleshy mass, tender, slightly sweetened, where one may find a little starch localized in the outer parts. Boiled with water it constitutes a light food rather delicate.

Here are some analyses of headed cabbage (*Brassica oleracea capitata*), of green or ordinary cabbage, of cauliflower (*B. o. botrytis*) and of so-called Brussels sprouts. They relate to a kg.:—

	Headed Cabbage.	Green Cabbage.	Cauliflower (average).	Brussels sprouts.
Water	899·7	900	909	828·0
Albuminous matter	18·9	33	24·8	38·0
Starchy matters, etc.	48·7	57	45·5	96·20
Cellulose	18·4		9·1	17·90
Fats	2·0	—	3·4	5·80
Mineral matters	12·3	15	8·3	14·10

We shall give later the detailed analysis of the mineral matters of these vegetables.

Sour crout is obtained by soaking in salt water, with the addition of juniper berries, pepper, etc., the leaves of headed cabbage previously cut into thin strips. The water is renewed after ten or twelve days. A fetid and lactic fermentation develops which leaves, after washing and cooking, an acidulous aliment, easy to digest and nearly free from starch.

The *onion* is the radical bulbous stalk, often very developed, of the *Allium cepa* (*Liliacea*). The *leek* is the elongated bulb of the *Allium porrum*. The detailed composition of these two vegetables deserves to be better known: we only know that they contain a volatile essence piquant to the eyes and nose, formed of allylic ethers. Ordinary starch is not found in these two vegetables.

Garlic is formed by small bulbs or cloves of *allium sativium* (Liliaceæ).

It is chiefly used as seasoning. We find a very irritating sulphurated oil in it, sulphate of allyle exciting to the secretion of the intestine and stomach. After boiling in water, garlic can easily be eaten. It contains starchy mucilaginous and sugared materials.

Here are two analyses of onion and garlic due to M. Balland :—

	Pink Onion.	Garlic.
Water	83·50	58·00
Nitrogenous matters	1·62	6·52
Fatty matters	0·10	0·15
Extractive matters, starchy matters, etc.	13·69[1]	32·68[2]
Cellulose	0·50	1·22
Ash	0·59	1·43

These three last vegetables are almost entirely used as condiments.

All green vegetables are very rich in water ; it rarely falls below 83 per cent. and can rise to 94 per cent. and more. This water holds in solution with a small proportion of albumins, gums and mucilages, various salts in which alkalies predominate ; 100 grms. of fresh green cabbage gave me 1·09 of ash, composed of 0·338 insoluble salts and 0·752 soluble salts. These answered to an alkalinity of 0·06 grms. of soda, NaOH, measured by phenolphthalein.

Here is a complete analysis of the ash of some of these aliments. We shall there notice the predominance of alkaline phosphates, especially of phosphate of potassium and the surprising richness in silica of some of these vegetables.

Centesimal Composition of the Inorganic Matter of some Vegetables.

	Asparagus.	Onion.	Cole-cabbage.	Cauliflower.
Water in 100 fresh parts	94	86	87	91
Salt ,, ,, ,,	0·436	0·74	1·40	0·99
Composition of 100 parts of these salts :—				
K^2O	24·0	25·1	26·8	26·4
Na^2O	17·1	3·2	13·9	10·2
CaO	10·9	21·9	14·8	18·7
MgO	4·3	5·3	4·2	2·3
Fe^2O^3	3·4	4·5	1·6	0·4
P^2O^5	18·6	15·0	13·2	13·1
SO^3	6·2	5·5	12·8	11·4
SiO^2	10·1	16·7	5·2	12·8
Cl	5·9	2·8	7·5	6·1

[1] 2·06 of which are sugar. [2] With only some traces of sugar.

VARIOUS VEGETABLES

TUBERCLES : POTATOES, SWEET POTATOES, YAMS, ETC.

Potatoes.—It is the type of aliments stored up by the underground portion of the stem. It is found on the radical parts of the *Solanum tuberosum*, of the family of Solanaceæ, a plant imported from South America into Italy and Spain towards the middle of the sixteenth century, afterwards into England by Sir Walter Raleigh in 1586. In France since that time it has been cultivated in La Franche-Comté and Burgundy where it was introduced by the Spaniards, also in Lyonnais. But the unfortunate prejudice which for a long time asserted that it caused leprosy, prevented its general use until the seventeenth century, when Parmentier caused it to be definitely accepted.

At the present time the potato, in addition to bread and meat, is the most general and valuable aliment. Since it has become popular we can say that famine has disappeared from Europe.

The production of the potato, which in France alone was 42,000,000 cwt. in 1852, reached 100,000,000 in 1862 and 130,000,000 in 1896 in that country.

To-day more than forty varieties of this valuable vegetable can be counted.

The analyses carried out by M. Balland (*C.R.* t. CXXV, p. 429) on the principal kinds : Early Rose, Hollande, Pomme de terre d'Auvergne, de Bourgogne, Hative Saint-Jean, Royale bleue, Saucisse rouge, Mille yeux, Vilelotte, Rosace d'Allemagne, gave him when fresh the following results for 100 parts.

	Average.	Minimum.	Maximum.
Water	74·98	66·10	80·60
Nitrogenous matters	2·08	1·43	2·81
Fatty matters	0·15	0·04	0·14
Starchy and sugary matters	21·01	15·58	29·85
Cellulose	0·69	0·37	0·68
Ash	1·09	0·44	1·80

It will be noticed how small the amount of proteid materials is in this aliment ; M. Balland found 1·43 of nitrogenous matter in 100 fresh parts of Early Rose of Bresse ; 2·32 in 100 parts of the same variety cultivated in Brittany ; 1·78 in the Hollande of Gatinais ; 2·57 in the Hollande of Pontoise ; 1·51 in the saucisse rouge of Niévre and Gatinais.

The proportion of water appears to be independent of the variety and to depend rather on the rain and the nature of the soil. The Early Rose gave 80·5 per cent. of water in Burgundy and 67·50 in Brittany.

The small new potatoes differ little in composition from those which are fully developed.

The juice of the potato contains asparagin, malic acid and a glucoside soluble in alcohol.

Potatoes cooked in water do not appreciably change in weight. Fried in fat or oil, they retain about 38 per cent. of water and absorb 4 to 9 per cent. of fatty matters. Three kgs. of potatoes cooked in water, or 1,200 grms. of fried potatoes, represent very nearly the nitrogenous and starchy alimentary matter in a kilogramme of ordinary white bread.

The following analyses due to J. Herapath (*Chem. Soc. Journ.* II., 4°) give the composition of the mineral matters in some of the principal varieties of this valuable aliment :—

COMPOSITION OF THE ASH OF POTATOES (ENGLISH VARIETIES).

	White Apple.	Prince's Beauty.	Maggie.	Fortyfold.
Ash for 100 parts of fresh plants .	1·30	1·06	1·09	0·88
Composition of 100 parts of ash :				
1st. Soluble ash :—				
CO^2	21·06	16·67	18·16	13·33
SO^3	2·77	4·94	5·60	6·78
P^2O^5	5·72	8·92	6·67	11·43
K^2O	53·47	54·17	55·73	53·03
Na^2O	Traces	Traces	Traces	Traces
NaCl	"	"	"	2·09
2nd. Insoluble ash :—				
CO^3Ca	0·84	2·05	1·95	2·29
CO^3Mg	3·53	0·27	2·56	0·57
SO^4Ca	Traces	Traces	Traces	Traces
$(PO^4)^2Ca^3$	3·36	0·68	5·37	2·86
$(PO^4)^2Mg^3$	9·25	12·30	5·54	7·62
$(PO^4)^2Fe^2$ & Mn^2	Traces	Traces	Traces	Traces
SiO^2	"	"	"	"
	100·00	100·00	100·00	100·00

These analyses show :—

1st, the great richness of these aliments in potash, and the excess of this base over the quantity necessary to constitute the neutral phosphate. The potash, in the potato, is united principally with citric and malic acid. 2nd, the very large proportion of magnesia in comparison with the lime. 3rd, the absence of chlorides and salts of soda, except in the case of one variety.

According to Rübner, if a man is exclusively nourished with potatoes, 9 per cent. of the dry substance, 30 per cent. of nitrogen, and 7 per cent. of carbo-hydrates remain in the fæces which become soft, acid and fetid. On the contrary, purees of potatoes made with the addition of milk or butter are much better absorbed. There only remains in the intestines 4·5 per cent. of substances calculated dry and 19 per cent. of nitrogen. The poverty of the

potato in proteid principles, and these last observations, show that it is far from being a complete and sustaining food. But it has this advantage over bread that, far from acidifying the blood as is the case with the latter, they alkalize it. Unfortunately they cause fatness and obesity.

Sweet Potatoes, Yams, Jerusalem Artichokes, etc.—With regard to the other amylaceous tubercles, we shall confine ourselves to a few indications .—

The *sweet potatoes* are formed by the ovoid tubercles, white or yellow, formed on the roots of the *Convolvulus batatas.* In taste and composition, the sweet potato very much resembles the ordinary potato. It is rich like the latter in fecula and poor in albuminoids. It contains : Water, 66 to 79 per cent. ; fecula, 9 to 16 ; sugar, 10 to 2 ; fatty matter, 1 to 0·3 ; albuminoid matters, 1·2 to 1·5 ; salt, 2·6 to 3·5 per cent.

Yams are also radical tubercles, often very developed (they may be more than a metre in length and almost that in diameter) formed on the roots of different dioscoreaceæ ; *Dioscorea sativa, D. Batatas.* These products are used for the nourishment of man in India, Guiana, China, Japan, Florida, Virginia, etc.

The *China yams* answers to the following composition : Water, 83·4 to 87 ; fecula, 15 to 16·8 ; cellulose, 0·4 to 1·5 ; proteid substance, 2·4 to 2·6 ; pectates, citrates, phosphate of potassium, magnesium, calcium . . . . 1·4 to 2 per cent. We see that the yam is nearly as rich in starch as the potato, and a little less poor than the latter in proteid substances.

Manioc is derived from the tubercles of a plant, the *Jatropa manihot*, of the family of the Euphorbiaceæ of the group of castor oil plants. It has two principal varieties : the *Yuca dulce and the Yuca brava ;* the latter is poisonous owing to a hydrocyanic compound[1], but after cooking it can be eaten with impunity. The tubercles of manioc, often very large, are coarsely grated, their pulp drained and then slightly roasted in an earthen vessel. Thus we obtain *cassave*, a food which forms the basis of alimentation in many countries of South America, India and the Antilles, etc.

Payen (*loc. cit.*) has given for 100 fresh parts of tubercles of peeled manioc, the following composition :—

Water	67·65
Fecula	23·10
Sugars, gums, etc.	5·53
Nitrogenous matter	1·17
Cellulose, pectose, etc.	1·50
Fatty matters	0·40
Mineral substances	0·65

[1] Payen (*Comptes Rendus*, t. XLIV, p. 404) has recovered four milligrammes of hydrocyanic acid from 100 grms. of pulp. It seems to be found in the form of a very unstable glucoside.

The *Jerusalem artichoke*, or *Helianthus tuberosus*, originally from Brazil, bears on its running stem a number of pedicle shoots the size of a pear, covered with a red and green outer skin, and containing in their interior a white translucid pulp formed of a cellular tissue containing inulin in place of starch, and a juice rich in sugar and different salts (tartrates, malates, citrates, phosphates and sulphates). This pulp can be eaten when cooked, and much resembles the artichoke in taste, consistence and composition. Its taste is slightly disagreeable. 100 parts, when fresh, contain :—

	100 parts contain in a fresh state		
	Braconnet.	Payen.	Average (J. Koenig).
Water	77·2	76·0	79·24
Dextrin, incrystallizable sugar	14·8	14·7	16·29
Inulin	3·0	1·90	1·49
Cellulose, etc.	1·22	1·50	—
Gums	1·08	—	1·76
Glutin, albumin	0·99	3·10	0·14
Oil, cericin	0·09	0·20	—
Extractives	—	1·30	—
Citrate and malate of potash	1·15	—	0·10
Citrate and tartrate of lime	0·10	1·30	18·0
$SO^4K^2, KCl, PO^4K^2H, PO^4CaH, SiO^2$	0·42		
	100·05	100·00	100·00

The *bulbous chervil* is a vegetable too little cultivated, of a rather delicate sweetish taste. It is the fleshy and thick root of the *Choerophyllum bulbosum* (*umbelliferæ*). It has, according to Payen (*C. Rend.* t. XLIII, p. 770), the following percentage composition :—

Water	63·6
Fecula and congeners	28·6
Cane sugar	1·2
Albumin and other nitrogenous matters	2·6
Fatty matters	0·35
Cellulose, pectose, pectic acid	2·10
Mineral substances	1·5

The bulbous chervil is richer than the potato in feculent and albuminous substances.

Roots: Turnip, Turnip Radish, Carrots, Salsify, etc. The *turnip* is the fleshy, spindle-shaped root of the *Brassica napus esculenta*.

It is an aliment very rich in starch, of a slightly aromatic, sugary savour, slightly piquant, differing much in composition and taste according to the soil, climate and variety.

The *radish* is the radical succulent part of the *Brassica oleracea caulo-rapa.*

Salsify, the cultivated root of the *Tragopogon pratensis*, is also a starchy vegetable like viper's grass, the roots of which, spindle-shaped, black outside and white inside, contain chiefly some starches, mucilages and mannite.

The *carrot* is the radical tap root, completely modified by kitchen garden culture, of the *Daucus carotta* (*umbelliferæ*). It is a fleshy, sweetened and perfumed root suitable for the nourishment of man and animals. It contains some starch, cane sugar, mannite, fatty and essential oils, a colouring hydro-carburet carottine, asparagin and some malates and phosphates of potassium and lime, etc.

The tap fleshy root of another umbelliferæ, the cultivated parsnip, is also a healthy aliment sweet to the taste and slightly aromatic.

Here are some average analyses of these different roots :—

Centesimal Analyses of some Comestible Roots (according to J. Koenig).

	Carrots.	Radishes.	Turnips.	Parsnips.	Radish.
Water	86·8	85·9	87·8	82·0	86·9
Starchy matter, etc., non-nitrogenous	9·2	8·2	8·2	} 14·1	6·8
Cellulosic substances	1·5	1·7	1·3		
Nitrogenous matters	1·2	2·8	1·5	1·1	1·6
Fatty bodies	0·3	0·21	0·2	0·5	0·1
Mineral matter	1·0	1·17	0·9	1·0	1·0

Beetroot is the fleshy and sweetened tap root of the *Beta vulgaris.* It is employed chiefly for the nourishment of cattle and the production of ordinary sugar. Its red variety eaten in salad appears frequently on our tables. The composition of the beetroot is very variable according to its culture and its variety.

Here is the average analysis of the comestible beetroot :—

Water	87·50	Starchy matter, sugars .	8·90
Nitrogenous matter . .	1·34	Cellulose	0·98
Fatty bodies . . .	0·14	Ash	1·14

Beetroot only contains from 6 to 15 per cent. of saccharose.

Flours of Amylaceous Vegetables.—For ordinary alimentation and for invalids some comestible flours, of which I will only say a few words here, are prepared with the bulbs, tubercles and roots which we have just studied.

Tapioca is a fecula obtained from manioc. In the course of the preparation of *cassava* (see p. 245) the pulp of manioc which is thrown on large strainers gives a juice which carries with it a certain number of grains of starch. They are collected, washed

and dried in the air ; thus we obtain *moussache*. This starch, slightly heated whilst damp on metallic plates, swells, becomes translucid and takes the name of *tapioca*. It is an aliment essentially amylaceous, formed of agglomerated and elasticopaline lumps. Ordinary tapioca, which serves to make our soups, is often obtained, at the present time, by submitting to the same treatment the starch of rice or the fecula of potato.

Arrowroot is a fecula coming from the *Maranta indica* (*Amomacæ*) of the Antilles. Its grains, slightly translucid, almost truncated, give an agreeable jelly when cooked with water. This flour is often adulterated with the fecula of the potato. Arrowroot contains 0·9 per cent. of albumin and 84·41 per cent. of fecula.

Sago contains 87 per cent. of starch and only some traces of albumin. It is obtained from the pith of different palms. It sometimes takes the place of tapioca. It is used in cases of slight enteritis, during convalescence, etc.

Salep is especially an invalid food. It is furnished by the bulbs of different *orchis*. It contains gums, mucilages and much starch. On boiling with water it takes the consistence of jelly. It is supposed to be fairly nourishing.

XXII

MUSHROOMS—HERBACEOUS VEGETABLES—VEGETABLE FRUITS

GREEN or herbaceous vegetables enter into our alimentation to a very appreciable extent. I have said elsewhere that, in usual French customs, these aliments represent, on an average, 12 to 13 per cent. of the weight of the daily portion, drinking water not included.

They are, in general, poor in nutritive principles: we find few fatty bodies and little starch, sugar and albuminoid matter in them. None of them give, after cooking, more than 2 to 3 per cent. of assimilable carbo-hydrates, amongst which we must reckon inosit, mucilages and gums, the assimilability of which is imperfect or doubtful. But, as has already been said, these aliments bring us an abundance of salts with organic acids (malic, citric, tartaric, oxalic, succinic, quinic, etc.) and of salts with alkaline or terreous alkaline bases, which furnish to the cells and blood the potassium, magnesia and lime which are indispensable to them. These matters vary in these products from 4 to 2 per cent. Green vegetables and fruits proper are therefore aliments at once refreshing and alkalizing.

These carbo-hydrates are: starch, inulin, dextrins, mucilages, cellulose and feebly digestive gums; cane sugar, glucose and levulose, sometimes mannite and some special sugars such as erythrite, dulcite, sorbite, inosit, galactose, etc.

The albuminoid matters of green vegetables are:—

Albumins, non-precipitable by dilute acetic acid and coagulable by heat; *caseins* and *vegetable legumins*, substances very slightly soluble in water where they only appreciably dissolve in the state of salts of potassium and sodium. Weak acetic acid precipitates them from their solutions; rather strong acids and alkalies, or their carbonates, re-dissolve them. By hydrolysis, these legumins split up into amino-acids: leucin, tyrosin, glutanic and aspartic acids, etc.

With these substances it is necessary to connect:—

1st. The *cyto* and *nucleoproteids* which may contain from 1·5 to 3 per cent. of phosphorus and which heat and water splits up into nucleinic acids and coagulated albuminoids.

2nd. *Edestin*, a crystallizable substance generally united to

phosphoric acid, as we have already pointed out, in the grains of cereals (p. 216). It greatly resembles casein.

3rd. *Gliadin*, or vegetable gelatin, soluble in water alcoholized to 70°. It is found in vegetables, likewise in cereals and fruits.

4th. *Conglutin*, very similar to the preceding, having the same characters of solubility in water, acids and alkalies. It splits up, in the manner of legumin, during the action of digestion or under the action of dilute acids.

The fats of herbaceous vegetables are variable and in very feeble proportions. We often find in them those lecithins of which we have already spoken à propos of dry vegetables and the flours of cereals.

The green pigment of vegetables, chlorophyll, is a nitrogenous phosphorated colouring matter soluble in alcohol and ether and seems to be indigestible.

In this chapter we shall study successively *mushrooms, herbaceous vegetables and vegetable fruits.*

Mushrooms.—These aliments, by reason of their taste and richness in nitrogenous principles, deserve to be considered apart. They contain in general: 90 to 92 per cent. of water, except truffles which only give 72 to 73 per cent. Their very diverse fixed principles are:—

1st. Nitrogenous matters about which we have little information. Three-fourths consist of proteid substances insoluble in water. Out of 4 to 5 per cent. of nitrogenous bodies contained in ordinary comestible mushrooms and 8 to 10 per cent. in the truffle, there are only 0·8 to 1 per cent. of coagulable soluble albuminoids. A good part of the proteid bodies is then in the state of insoluble globulins and nucleo-albumins. Alcohol at 70 per cent. carries off a part of the nitrogenous principles and with them the perfumes of these aliments. Another part is dissolved in water. When it is concentrated by heat, this solution takes somewhat the aspect and savour of extract of meat. Besides different nitrogenous substances, boiling water also dissolves some viscous or mucilaginous matters, probably of the nature of gums or starches, some fermentable sugars in a small quantity, dextrin, and above all mannite, especially in the case of truffles.

2nd. Ether carries off from mushrooms, especially in the case of truffles, some very odorous fatty matters in a relatively high proportion. They are to a large extent composed of olein and margarin and of a substance which alkalies do not saponify—viz. *agaracin;* probably a kind of cholesterin.

Of organic salts we find in mushrooms some malates, citrates, tannates, fumarates, pectates, etc.[1]

[1] Fumaric acid should be absent in truffles, according to Lefort.

The white parts of truffles or ordinary mushrooms are formed chiefly of cellulose ; the coloured or black part is rich in spores and sporanges. Nothing is known of the nature of this special brown pigment.

The mineral salts of mushrooms are chiefly formed of the phosphates of potash and lime with a small quantity of sulphates, chlorides and silicates of soda, ammonia, calcium, magnesia and iron.

Here is a table of the composition of some of these aliments :—

PERCENTAGE COMPOSITION OF SOME MUSHROOMS.

	Black Truffle.	Bed Mush-rooms.	Esculent Boletus.	Morils.	Edible Boletus.	Edible Agaric.
Water	70·5	90·5	90·6	90·0	91·3	90·10
Nitrogenous matter .	8·4	4·6	4·9	4·4	3·6	2·68
Coagulable albumins .	0·6	0·7	—	—	—	—
Cellulose	5·2	3·2	2·44	2·96	0·6	0·64
Fatty matters . . .	0·55	0·25	0·65	0·56	0·2	0·13
Mannits and sugars .	11·00	1·15	0·6	0·72	3·7	
Malates, citrates, fumarates	0·65	1·35	0·83	1·36	0·6	5·14
Mineral salts . . .	1·49	—				1·31

Mushrooms preserved by dessication still contain from 10 to 20 per cent. of water.

Several poisonous mushrooms, such as the woolly, lose their toxic properties by drying or boiling with water.

Herbaceous Vegetables.—We comprise under this head the vegetables of which the leaves and tender parts are eaten, cooked or raw, such as salads of all sorts (lettuces, endive, corn-salad, cresses, rocket, etc.), sorrel, rhubarb, spinach, white beet, tetragon, etc., etc.

As we have already said, these products of the kitchen garden introduce into the system very little assimilable organic matter, but much water and especially salts rich in potash, soda, lime, magnesia, phosphates, silica, and finally iron under the form of hematogen, etc. Out of eight parts of fixed matters contained in 100 per cent. of fresh lettuce (the rest being formed of water), there are 1·24 per cent. of mineral salts. Out of twelve fixed parts left by 100 per cent. of spinach taken in a fresh state, 1·98 or a sixth is formed of inorganic salts.

In 100 parts of ash left by Roman lettuce we find $K^2O = 25{\cdot}3$; $Na^2O = 35{\cdot}3$; $CaO = 11{\cdot}9$; $MgO = 4{\cdot}3$; $Fe^2O^3 = 1{\cdot}3$. And for acid radicals : $P^2O^5 = 10{\cdot}9$; $SO^3 = 3{\cdot}9$; $SiO^2 = 3{\cdot}0$; $Cl = 4{\cdot}2$. In spinach we have for 100 parts of mineral matters $K^2O = 16{\cdot}6$; $Na^2O = 35{\cdot}3$; $CaO = 11{\cdot}9$; $MgO = 6{\cdot}4$;

Fe^2O^3 = 2·3; P^2O^5 = 10·2; SO^3 = 6·9; SiO^2 = 4·5; Cl = 6·3. The richness of this ash in bases will be noticed especially in alkaline bases, as also the abundance of iron.

These aliments, essentially aqueous, contain however some albuminous substances richly phosphorated, lecithins, fats, also some mucilaginous and starchy matters which are easily assimilable. As Kniriem has shown, a part of the cellulose of herbaceous vegetables, when in the young state, is like that of fruits, re-absorbed in traversing the digestive tube.

The total of all these nutritive matters rarely rises in the case of green vegetables to more than one-twentieth of the total weight of fresh aliment.

The starch may be replaced in these products (and it always is in the comestible parts of the family of Synantheireæ, such as chicory, lettuces, artichokes) by inulin; this observation is important from the point of view of the alimentation of glycosurics. In the place of ordinary sugar we sometimes find mannite in many of these foods.

The intestinal utilization of herbaceous vegetables is always imperfect; after the ingestion of the green cabbage, about 15 per cent. of fixed matters remain in the fæces, 18 per cent. of total nitrogen, 15 per cent. of carbo-hydrates, 6 per cent. of fatty bodies escape intestinal absorption. It is almost the same in the case of the other green vegetables.

The cellulose of young shoots is digested by man in about the proportion of 50 per cent. The parts of these foods which remain thus in the fæcal matters prevent their becoming hard and hinders constipation; hence the qualifying term "refreshing" often given to green vegetables.

The herbaceous vegetables can be divided into *neutral* and *acidulous* classes: Chicory, lettuces, corn-salad, dandelion, cardoon, beet, tetragon, celery, spinach, etc., come in the first category; sorrel, rhubarb, etc., in the second. These vegetables are eaten cooked or raw.

We can only quote here the chief:—

Celery is formed of a young shoot, blanched by sheltering it from the direct action of light, of the *Apium dulce* (umbelliferæ). It is an aromatic aliment rich in mucilage which contains an essence and some aromatic products acting a little on the heart; it has the reputation of being somewhat aphrodisiac. *Bleached dandelion*, which is eaten in salad, is only a bitter and tonic chicory reared in caves protected from the light.

Lamb's lettuce or *corn-salad* is a valerian. *Lettuce* is rich in alkaline citrates. *White beet* or *beet*, the leaves of which, and especially the stalks, eaten cooked like those of cardoon, contain a slightly laxative principle. It is a Chenopodiaceæ. It is the same with *spinach* (*Spinacia oleracea*) rich in mucilaginous

principles and sugars, which accompany some oxalates and various organic salts of potassium and lime.

The *acid herbaceous vegetables* owe their acidity sometimes to oxalates, sometimes to acid citrates and malates.

Sorrel and *rhubarb* belong to the family of Polygoraceæ; their leaves and young shoots are eaten. These are aliments which should not be given to gouty, arthritic, uratic and oxaluric people. These vegetables owe their acidity to tetroxalate and bioxalate of potassium.

Here is their composition according to M. Balland:—

	Sorrel.	Rhubarb (petioles for entremets).
Water	91·40	94·50
Nitrogenous matters	2·74	0·43
Fatty matters	0·40	0·49
Starches, etc.	3·57	3·47
Cellulose	0·60	0·54
Ash	1·29	0·57
	100·00	100·00

Cresses of the family of *Cruciferæ*, provide us with thick mucilaginous leaves, of a piquant taste, exciting the appetite owing to the allylic essence which they contain. This vegetable is very rich in salt. M. Chatin was the first to point out the iodine in it which appears to exist in the organic state. It is a diuretic, refreshing and anti-scorbutic aliment.

Here is, according to J. Koenig and M. Balland, the composition of some of the vegetables of which we have just spoken:—

PERCENTAGE COMPOSITION OF SOME COMMON VEGETABLES.

	Spinach.	Celery (leaves).	Cos Lettuce.	Cabbage Lettuce.	Cresses.[1]	Red Beetroot for salad.[1]
Water	88·47	85·57	92·50	94·93	90·8	84·80
Nitrogenous matters	3·49	2·26	1·26	1·41	2·87	3·09
Fatty matters	0·58	0·56	0·54	0·31	0·21	0·05
Sugar	0·10	0·94	—	—	3·19	9·14
Gum, starch, mucilages	4·34	6·91	3·55	2·19		
Cellulose	0·93	1·32	1·17	0·73	1·21	1·18
Ash	2·09	1·93	0·98	1·03	1·72	1·74

Vegetable Fruits.—The *vegetable fruits* are the tomato, mad-apple, all-spice, etc.; and to these may be added cucumbers, melon, pumpkin, etc.

The fruit of *Lycopersicum solanum* or tomato is a red berry

[1] According to M. Balland.

filled with an acid pulp at the same time slightly perfumed and of a slightly disagreeable taste. It is rich in acid salts (citrates, malates); but *contrary to general opinion, scarcely a trace of oxalates is found.* This fruit agrees particularly with arthritics, gouty and uratic people when their stomach digests it well.

Tomato contains, according to W. Dahlen: *water,* 92·37; *nitrogenous matters,* 1·25; *fatty matters,* 0·33; *sugars,* 2·53; *non-nitrogenous matters,* 1·54; *cellulosic matters,* 0·84; *ash,* 0·63. Balland found 95·2 per cent. of water; 0·89 of nitrogenous matters and 2·92 of non-nitrogenous soluble substances (sugars, etc.).

The fruit of *Solanum melongena,* or egg plant, which grew originally in India, forms elongated berries, of purple colour,[1] filled with a white bitter juice which is generally squeezed out by cutting up and draining the pulp, the pungency of which disappears on cooking. It is a fairly digestible aliment if well cooked, but it is difficult to prepare. Balland found: *water,* 92·30; *nitrogenous matter,* 1·34; *fatty matter,* 0·17; *extractive or starchy matter,* 4·77; *cellulose,* 0·87; *ash,* 0·55.

Of fruits of the *Capsicum,* and coming from the same family, there are many varieties. One kind, sweet, in large inflated berries, more than a decimetre in length, is much eaten as a *hors-d'oeuvre* in the South of Europe. Its episperm is filled with a sweetish pulp, slightly perfumed, containing seeds that are thrown away. A variety of this fruit from 2 to 5 centimetres in length, of a vivid red colour when ripe, is used as a condiment to flavour dishes and to excite the appetite by reason of its sharp and aromatic savour.

The Chili of Cayenne, of a still more violent bitterness and very slight aroma, is dried, pulverized and sometimes used in place of pepper; it is a dangerous condiment if habitually used.

Melon, water-melon, cucumber, pumpkin, gherkin, and gourd, are furnished by the family of the Cucurbitaceae.

The fruit of the melon (*Cucumis melo*) is succulent, very aqueous, slightly albuminous, rich in saccharose, scented when ripe and of good quality, but very slightly nutritive. Its seeds are slightly emetic.

Cucumber (*Cucumis sativus*) has an aqueous, tasteless pulp, slightly sweet. It is often eaten pickled in vinegar, raw or cooked and prepared in different ways.

Gherkin is a kind of cucumber gathered before its maturity. The *caper* is the little ovoid fruit of the caper bush (Capparideæ). Both are preserved in vinegar and serve as condiments.

The water-melon is especially sought after for the sweetness of its pulp which is composed almost entirely of water and saccharose.

[1] The white variety is poisonous.

Here are, according to J. Koenig and M. Balland, three average analyses of melons, cucumbers and pumpkins :—

	Melon.	Cucumber.	Ordinary Pumpkin.
Water	90·38	95·20	94·5
Nitrogenous matter	1·0	1·18	0·35
Fatty matter	0·32	0·09	0·06
Starches, sugars, etc.	6·53	2·21	4·08
Cellulose	1·09	0·78	0·64
Ash	0·68	0·44	0·37

The pumpkin, red or yellow, forms big flattened fruits weighing as much as 10 and 20 kgs. Its pulp, which is rather hard, is eaten after cooking. It is sweet in taste, slightly aromatic and easy to digest. It is a very aqueous aliment. Its whitish seeds, tasting of almond, are anthelmintic.

The gourd or calabash produces some comestible and poisonous varieties, particularly that in the form of a gourd. That with yellow pulp is very bitter.

Gourd contains 85 per cent. of water and 0·4 per cent. of mineral matter.

In fruits with neutral pulp, or almost neutral to litmus, such as the melon, water-melon, etc., the sugar is chiefly saccharose, but we may also find some levulose and levogyrate matters with considerable left rotation, the proportion of which varies during the whole time of ripening (Commaille).

XXIII

FRUITS PROPERLY SO CALLED

FROM the point of view of their composition and their utility, the fruits which appear on our tables for "dessert," and which form an agreeable and rational addition to the repast, may be divided into three groups :—

The aqueous acidulous fruits, generally sweetened and perfumed, which the vine, orange-tree, gooseberry bush, and especially the trees of the family of the Rosaceae, provide us with.

The properly so called sweetened fruits, of a flavour neither acid nor fatty, produced by the fig, date and banana trees, etc.

Lastly, *the starchy or oily fruits*—nuts, chestnuts, almonds, hazel-nuts, cocoa, cocoanut and other exotic fruits.

Aqueous Acidulous Fruits.—To this group belong apples and pears with their very numerous varieties ; plums, peaches, apricots, nectarines, quinces, cherries, medlars, strawberries, raspberries, etc., all furnished by the Rosaceæ ; grapes, currants, black currants, pine-apples, orange, lemon, pomegranate, etc., originally come from very different families, etc., and some fruits from tropical countries.

These fruits are all remarkable for their richness in water (72 to 90 per cent.) ; their very feeble amount of starchy matters, which almost entirely vanishes when ripe ; their poorness in albuminous principles, the total weight of which rarely rises to ½ per cent. ; their richness in saccharin, which varies from 4 to 24 per cent. ; their constant acidity, and finally for this very agreeable perfume of their juice. A part of their cellulose becomes soluble in the intestines of man. These fruits are then in reality rather aqueous, refreshing aliments, more pleasing to the stomach and palate than plastic aliments, unless they are consumed in very great abundance, as in the grape cure.

Their acidity, due in a large measure to some acid salts (malates, citrates, tartrates, fumarates, etc.), varies from 0·2 to 1·5 per cent. These salts, with alkaline bases, are transformed in the system by the complete combustion of their organic part into soluble carbonates which alkalize the humours, as we have already said.

At the same time, by reason of the quantity of water that they provide and their special acidity, these fruits are, moreover, often a little diuretic and laxative, especially if they are not perfectly ripe.

The saccharin matters which form the greater part of the substances dissolved in their pulp, are formed by a mixture, in nearly equal parts when ripe, of glucose and levulose with a little saccharose.

Here is the average percentage composition of some of the principal fruits furnished by the Rosaceæ :—

Composition of the Usual Various Fruits of the Rosaceæ.

	Apples[1] (average).	Pears.	Plums.	Green-gages.[3]	Dried Prunes, Selected.	Mirabelle Plums.[6]
Water	84·79	83·03	81·18	78·30	19·80	79·4
Albuminoid matters, etc.	0·36	0·36	0·78	0·42	2·37	0·4
Free acid [2]	0·82	0·20	0·85	0·38	—	0·5
Sugar	7·22	8·26	6·15	10·9	46·3	4·0
Various non-nitrogenous matters	4·81	3·54	4·92	9·28[4]	25·14[5]	10·1
Cellulose	1·51	4·30	5·41	0·62	4·13	5·0
Ash	0·49	0·31	0·71	0·48	1·86	0·6

Composition of the Usual Fruits of the Rosaceæ (*continued*).

	Peaches.	Apri-cots.	Cherries.	Quinces.[7]	Straw-berries (average).	Rasp-berries.
Water	80·0	81·2	79·82	71·70	87·66	85·7
Albuminoid matters, etc.	0·6	0·5	0·67	1·12	0·54	0·4
Free acid [2]	0·9	1·2	0·91	0·61	0·93	1·4
Sugar	4·5[9]	4·7[8]	10·24	6·70	6·28	3·9
Various non-nitrogenous matters	7·2	6·3	1·76	0·69[3]	1·01	0·7
Cellulose	6·1	5·3	6·07	18·79	2·32	7·4
Ash	0·7	0·8	0·73	0·47	0·81	0·5

[1] According to J. Jacquemin and H. Alliot, a typical apple, ripened to a nicety for making cider, contains for 100 parts : water, 83·2 ; sugar, 11 ; vegetable tissue, cellulose, 3 ; gums, pectase, 2·1 ; albumin, 0·20 ; malic, pectic, tannic, gallic acids ; lime, acetates, alkalies, oily and nitrogenous matters, 0·50.

[2] Expressed in weight of malic acid.

[3] Fatty matters.

[4] 0·24 of which are fatty matters.

[5] 0·40 of which are fatty matters.

[6] M. Balland's analysis.

[7] This weight of sugar appears small ; Balland has given 8·9 of sugar as an average.

[8] According to Balland, 8·1 of sugar.

[9] According to Balland, 6·2 of sugar.

1000 grms. of these various fruits leave an ash composed, according to Moleschott :—

COMPOSITION OF ASH OF 1,000 PARTS OF DIFFERENT FRUITS.

	Apples.	Pears.	Plums.	Cherries.	Straw-berries.
Total ash for 1,000 fresh parts .	3·65	3·57	4·80	6·58	7·56
K^2O	1·30	1·96	2·63	3·41	1·77
Na^2O	0·95	0·31	0·42	0·08	2·27
CaO	0·15	0·29	0·23	0·49	1·20
MgO	0·32	0·19	0·22	0·35	Traces
Fe^2O^3	0·05	0·04	0·12	0·12	0·50
P^2O^5	0·50	0·54	0·85	1·05	1·05
SO^3	0·22	0·19	0·15	0·34	0·33
SiO^2	0·16	0·05	0·15	0·60	0·20
NaCl	—	Traces	0·03	0·14	0·24

Let us again here note the simultaneous predominance in these ashes of potash and phosphoric acid, this latter moreover still being insufficient, even with the co-operation of the other acid radicals, to saturate the whole of the bases. Soda is relatively very abundant in the strawberry, also iron and lime, whereas there is a lack of magnesia in it. Figs, pears and plums give some traces of manganese.

In fruits arrived at maturity but kept dry, such as dried apples and pears, dried figs, raisins, prunes, etc., the water falls to 33 and even 30 per cent.

All these fruits are too well known, there should be any necessity for me to give here a detailed description. They provide, besides, innumerable varieties which are distinguished by their taste, perfume, and their capability for cultivation in most different climates.

The *apricot* comes to us from China. Its very bitter grains contain 74 per cent. of water and 18 per cent. of nitrogenous matters. They are fairly rich in a hydrocyanic glycoside. Those of the plum contain 45·5 per cent. of water, 7 to 8 per cent. of nitrogenous matters and 29 per cent. of oil. The *peach* which, in spite of its name (*persica*), has the same origin as the apricot, contains a kernel which may give per 1,000 grms. as much as 64 milligrammes of hydrocyanic acid (Balland). The alimentary qualities of these three kinds of fruit are too well known to need any description here. Their percentage composition shows us sufficiently their small intrinsic alimentary value.

The pear tree and apple tree are older than man in Europe. There are to-day innumerable varieties. Many kinds are eaten at our tables, others made into perry or cider.

The strawberry is also indigenous to our regions. The small wild strawberries have given to M. Balland : Water, 85·6 ; nitro-

genous matter, 1·36 ; fatty matter, 0·99 ; extractives, 8·85 (3·7 of which are sugar) ; cellulose, 2·56 ; ash, 0·64 per cent. We know that they contain a salicylic derivative which often provokes skin eruptions and which is strongly irritant.

To the fruits of the Rosaceæ we must add those that other families provide us with (*Ampelideæ, Grossularieæ, Aurantiaceæ*, etc.).

We shall confine ourselves here by giving the composition of the grape, orange, currant and pomegranate. Except in the case of black grapes, we are again indebted to M. Balland for the analyses.[1]

PERCENTAGE COMPOSITION OF ORDINARY FRUITS BELONGING TO VARIOUS FAMILIES.

	Currant.	Black Grape.	Chasselas Grape. Whole with skin and grape stones.	Chasselas Grape. Pulp only.	Dried Raisin. Pulp and Skin.	Orange.	Pomegranate Pulp without seeds.
Water	92·90	78·17	80·00	81·80	19·80	86·70	84·20
Nitrogenous matter	0·31	1·96	0·49	0·36	0·45	0·69	0·59
Fatty ,,	0·65	—	0·38	0·31	0·56	0·26	0·15
Sugared ,,	5·46[2]	14·36	17·69	17·23[3]	76·70	11·43[4]	11·86
Extractives and cellulose . .	1·43	0·59	1·24	0·23	1·85	0·93	2·91
Ash	0·15	—	0·20	0·07	0·64	0·28	0·29
Acidity . . .	—	0·79	0·20	0·198	—	—	0·220
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The *currant*, unknown to the Greeks and Romans, comes to us from Northern Europe, Siberia and Canada.

The *vine* is indigenous to Europe, Asia and Africa. The natural acidity of its fruit, expressed in sulphuric acid, varies from 0·03 grms. to 1·2 per cent. The volatile acids do not contribute to it. Its sugar may reach 25 grms. and more for 100 grms. of pulp, especially in the case of white vines and in warm countries.

The *lemon*, so often employed as a condiment, possesses an acidity pleasing to the stomach. Its juice and pulp have been prescribed in large doses, and it appears not without success, in many diseases : in dropsy, yellow fever, scurvy, etc. The citron in sufficient doses appears to be endowed with a pronounced diuretic power (Trinkowsky).

With the *aqueous acidulous* fruits containing 4 to 10 per cent. of acid (estimated in corresponding HCl) we shall place the *neutral* or *sugared fruits*, of which the banana, fig, date, etc., are types.

[1] *Annales d'hygiène et de médecine légale*, August 1900.
[2] 4·9 of which are sugar.
[3] 16·6 of which are sugar.
[4] 6·2 of which are sugar.

The family Morus provide us with numerous varieties of figs : violet, green, grey, and white. Nearly all are rich in sugar and well perfumed at maturity.

Here is, according to M. Balland, the comparative analysis of fruits in a fresh and dry state :—

	Fresh.	Dry.
Water	84·80	0·00
Nitrogenous matter	0·79	5·20
Fatty matter	0·32	2·10
Extractives	12·15[1]	79·94
Cellulose	1·23	8·06
Ash	0·71	4·70
	100·00	100·00

The date, produced by the *Phenix dactylifera* (Palm family), is a fruit with a resisting sweet and aromatic pulp. It forms the principal nourishment of the population of many countries of Northern Africa, Persia and India. The following analyses give their composition :—

For 100 parts of fresh fruit.	Morin.	Balland.
Water	43·6	24·50
Albuminoid and pectic matters	2·9	1·96
Tannic acid and glucose	47·9	67·10[2]
Inulin	Traces	—
Fatty matters	0·4	0·06
Cellulose	1·9	5·05
Mineral matters	3·3	1·32

The banana, originating from Southern Africa, provides alimentation for numerous people in the tropics, and is even used to make a special kind of bread. Here is the analysis of its pulp in a fresh state and of the flour which it provides[3] :—

	Pulp.	Flour.
Water	73·8	—
Cane sugar	8·5	—
Inverted sugar	6·4	—
Starch	3·3	66·1
Cellulose	0·2	1·6
Pectose	0·6	1·4
Nitrogenous matter	1·6	2·9
Organic acids, extractives	4·2	—
Mineral matters	1·1	2·2

[1] 8·3 of which are sugar. [2] 51·3 of which are sugar.

[3] Marcano and A. Müntz, *C. Rend.* t. LXXXVIII, p. 158.

The ash of this fruit is very alkaline and formed of phosphate of potash with a little phosphate of soda ; chloride of potassium constitutes about a quarter of its weight.

The *starchy or oily fruits* such as the nut, almond, chestnut, hazel-nut, cocoa and the fruit of the bread tree, etc., differ very notably from the preceding by their richness either in starch, sugar, oil or fats. These latter may rise even to 75 per cent. They are also further removed from them by their relative poverty in water, which rarely rises above 30 to 33 per cent. in fresh fruit; finally, by their nutritive value which is somewhat high. Here are some analyses of these aliments. The three first are from M. Balland (*loc. cit.*) :—

PERCENTAGE ANALYSIS OF SOME STARCHY OR OILY FRUITS.

	Nuts. (October).	Hazel-nuts (January).	Sweet Fresh Almonds.	Almonds of Cacoyer.	Chestnuts.
Proteid matters .	11·05	15·58	5·67	13–18	4·46
Fats and oils . .	41·98	61·16	2·19	45–49	0·87
Alkaloids . . .	—	—	—	1·5–2	—
Various sugars, etc.	17·5	13·22	0·42	0·3–2·6	19·90
Cellulose . . .	1·6	3·84	0·39	5–80	3·79
Starch	—	—	—	14–18	15·55
Ash	1·30	2·70	0·96	3–5	1·51
Water	26·50	3·50	88·0	5·6–6·3	53·71

The almonds of the amygdaleæ all contain a small quantity of asparagin (L. Portes).

It is quite remarkable to see in some of these fruits (nuts, almonds), the starch almost entirely disappear as in the acidulous and aqueous fruits ; in the case of others, such as the chestnut, we still find from 13 to 15 per cent. in the ripe fruit.

The bread tree (Artocarpaceæ) produces a greenish fruit, of the size of the head, containing near its surface 40 to 50 seeds similar to chestnuts and which are eaten roasted. The pulp which surrounds them, and which constitutes the principal part of this fine fruit, is richer in starch than proteid substances. The people of the Malay Peninsula and Oceania cook this pulp and feed on it like bread.[1]

[1] In the same family the *Brosimum galactodendron* or *cow-tree* give, on incision, a milk thicker than that of the cow, but of slightly acid reaction, on which the Indians of South America nourish themselves (Boussingault, *Comptes Rendus*, t. LXXXVII, p. 277). This vegetable pseudo-milk contains a waxy material fusible at 50°, partly saponifiable by alkalies ; a nitrogenous substance analogous to casein ; some saccharin

To the oily fruits we must naturally add the olive, from which, when ripe, we extract the ordinary oil. This fruit is not usually oily when it appears as a *hors d'oeuvre* on our tables. In fact, the olive is eaten in two ways : when quite green, before maturation, after being deprived of a sharp and extremely bitter matter by means of repeated digestions for several weeks in alkalized water. It is then kept in brine and afterwards eaten cooked or uncooked. Or else it is left to ripen on the tree until November, to shrivel up and grow black, then salted and eaten with a little oil, pepper and salt as an aperient.

According to the time of picking, this fruit has a very different taste and composition : the proportion of water, which was from 60 to 70 per cent. in the green fruit, falls to 25 per cent. in the ripe fruit. The very sharp and bitter substance found in the olive before ripening disappears to a great extent when the olive becomes black. In the green state we do not find there, or in very small quantities, any fatty principles, but it is rich in chlorophyll and mannite. These two last principles disappear and are gradually replaced by oil, in proportion as the fruit ripens (De Lucca, *C. Rend.* t. LIII, p. 380 ; t. LV, pp. 470, 506 ; t. LVII, p. 520).

Here are the analyses due to M. Balland (*loc. cit.*) of two kinds of comestible olives kept in pickle :—

	Long Olive.	Short Olive.
Water	75·40	73·30
Nitrogenous matter	0·76	0·67
Fatty matter	14·48	14·03
Extractives	8·04	9·81
Cellulose	0·90	1·81
Ash	0·42	0·38
	100·00	100·00

matters, some salts of potash, lime and magnesia. Boussingault has found the following composition for this milk :

Wax and saponifiable matters	35·2
Saccharin matters, etc.	2·8
Casein, albumin	1·7
Alkaline and terreous phosphates	0·5
Undetermined matters	1·8
Water	58·0

We see that this product slightly resembles ordinary milk.

XXIV

AROMATIC AND NERVINE ALIMENTS—COFFEE—TEA—COCOA—MATE, ETC.

APROPOS of aromatic aliments, which we shall now study, we shall here set out a series of considerations which we have not yet had occasion to develop, in reference to the various parts aliments play in the organisms. They are indispensable before going further.

Take the case of a man fatigued, ill, exhausted by acute pain, or simply seized with migraine. He is incapable of making the least effort. He is given a hypodermic injection of ether, or of benzoate of caffein in the first case, morphia in the second; he drinks a warm infusion of paulinia in the third; almost at once his forces revive, the pain is eased, the aptitude for physical or intellectual work is renewed, the functions become active and regular. The four agents used in these circumstances, ether, benzoate of caffein, morphia, paulinia, are however materials entirely unfit to furnish by themselves (not being sensibly transformed in the system) an appreciable quantity of utilizable energy; but they have the power of acting on the nerve centres, either to excite their activity or to ease the pain and to cause the nervous inhibitory action which it provokes, to disappear. These four substances are fitted in short to momentarily place the organism in a state of resistance or activity which allows it to react against the physical or functional decay which formerly prevented it utilizing its reserves.

From these medicaments, called *nervines*, to the stimulating aliments of which we are about to speak, there is only one step.

When to a tired man, overdriven by work, starved by watchings or want of food, we give a little alcohol, coffee, chocolate, a cup of soup, and *as soon as the absorbed food and even before its assimilable parts could have had time to pass into the vessels*, the sensation of well-being, energy and the forces revive, we must admit that the patient thus treated has found in these aliments the comfort of which he already feels, before they are scarcely absorbed, the source and the effective cause of the energy of which he becomes immediately capable. These foods have then acted on the nerves, which they have put in tension; they have caused the opposing influence created by fatigue, pain, inanition and perhaps toxins, to disappear. They have permitted momentarily the

individual in a state of collapse to consume, at the expense of his reserves, fats, sugars, nitrogenous matters, etc., till then indisposable, and from which he is able to draw henceforth utilizable energy.

These nerve-exciting aliments may contain, and often do contain, like cocoa, alcohol, broth, etc., combustible principles fitted to furnish energy to the animal system by their ulterior transformation ; in this case, they act first as *aliments* proper and as *excitors* of the centres of activity : heart, brain, sympathetic, etc.

But, if this aptitude of reinforcing the nervous actions which preside over the vital functions, or which cause the inhibition of the trophic centres provoked by fatigue, to cease, if this aptitude is particularly remarkable in coffee, tea, cocoa, alcohol, etc., it does not the less exist, although in a less degree, in all the other aliments. The sapid, odorous and aromatic properties of roast meat ; those of vegetables, of sweetened fruits ; those of the majority of dishes which please us, act equally on us distinctly before the principles which convey these properties have had time to contribute, by their assimilation and combustion, to the expenditure of energy necessary to function. A man is thirsty : he drinks abundantly and his thirst is immediately quenched before the water he has scarcely swallowed has penetrated as far as his blood. In the same way, hunger is appeased directly the stomach receives nourishment, and well before any of the alimentary principles, save the most volatile perhaps, have been re-absorbed. Deprived of everything in his terrible voyage to the North Pole, Nansen relates that he *drank with delight* the blood of seals which he succeeded in killing. This feeling of relief came to him the very moment when this blood penetrated into his stomach, before any part of it could have been really utilized. This was nevertheless neither a very savoury, rapidly digestible, nor diffusible aliment.

Besides their directly nutritive action, all aliments exercise then an exciting action on our nerves, and before nourishing us they dispose us to function, thanks to the reflexes of the gustatory, olfactory and digestive nerves which they awaken. They stimulate the trophic, assimilatory and even psychic nerve centres before penetrating into the blood.

This aptitude of thus placing the system in a state to resist fatigue, of furnishing more work, and of rapidly producing in a short time an amount of energy that it could only expend more slowly before receiving the exciting agent, seems to be particularly remarkable in the case of the alimentary products of which we are about to speak, in this respect—that the excitations which they provide, reach instantly a degree to which the usual aliments cannot always attain. Like the blow of the whip which draws

yet another effort from the used-up horse, at the end of his strength, in spite of the oats which he is meanwhile digesting, these aliments can rouse the organism to the point of excitation necessary for the excess of the momentary production of energy which it is desirable to obtain. An observation which I made by chance, appears to me suitable to explain these views. It happened that a mule, a very beautiful animal, refused for some months, every time he was harnessed, to a heavy cart, to make the effort that was demanded of him. Neither hay, oats nor blows were of any avail. He was about to be sold again, when a farm servant proposed to apply to him the means which he said they employed at his home to overcome the resistance of these beasts when they do not feel capable of doing the work which one expects from them. There was then added to his usual food two litres of wine daily, a very small quantity compared to the size of this animal, weighing as much as seven average men. From that day, and as long as the wine was mixed with its daily food, this mule did the best work. I saw it a year after, always on the same diet and always undaunted and resisting fatigue.

Thus this beast, which received oats in abundance and hay at discretion, would only furnish the effort necessary under the action of the special excitor which raised his nervous system to a state of sufficient tension. It is this state which ordinary food, provided that it be abundant, makes the highly bred animal, such as the racehorse, which is able suddenly to make a considerable effort which the ordinary horse cannot furnish, reach a state of tension to which the latter can nevertheless sometimes reach under the influence of stimulants which pure blood is able to do without.

These exciting aliments are not then *sparing aliments* as they are sometimes called ; they do not diminish the expenditure for the production of a given amount of work. The activity which they impress on the system only finds in them the excitant which puts into action the virtual energy of ordinary aliments. Its productive source is not found in these excitants. Allowance being made for the small proportion of assimilable alimentary matters which these agents may bring, the energy developed under their influence is entirely borrowed from the destruction of true aliments, and is proportional in every case to this destruction.

But we know that this expenditure of energy is composed of two quite distinct parts : the loss in caloric and the production of mechanical work. In the normal state and in the case of a healthy man, we have seen that this work only represents 8·5 to 10 per cent. of the total energy introduced by the aliments, and that a good workman can only furnish in the form of *useful work*,

6·5 to 9 per cent. of alimentary energy, cutaneous evaporation and caloric radiation representing fourteen-fifteenths of the total energy expended (see page 98). Now it is possible that under the influence of the nervine aliments a larger proportion of the disposable energy may be transformed into work: that the system, in short, may be put into such a state, that its output in heat being proportionally diminished, its yield in work is increased by a like amount. This hypothesis is moreover more plausible when we know that several of these nervine agents, coffee in particular, raise the central temperature whilst diminishing that of the periphery and, in consequence, thus diminishing the expenditure of heat lost by radiation and contact. Besides, this hypothesis of a more feeble loss of caloric energy by the skin under certain influences acting on the nervous system only, causes the same to take place in a healthy man as in the case of a febrile one. Here, manifestly, and for reasons of which the mechanism is in the innervation of the subject, the invalid, for a restricted diet, produces more heat than in the normal state, while at the same time he is incapable of furnishing a work proportional to the heat which he radiates, at least in the proportion in which the mechanical energy could produce itself, if he were in health. We see then that if the malady diminishes the aptitude for the production of work relative to the disposable and radiated heat, the improvement in the state of the individual, its tension under the influence of nervine stimulants, may reciprocally increase the aptitude to draw more work from a similar alimentation.

As Pawlow has proved, the aliments act upon the stomach, and even upon the intestine, first by a psychic effect. The dog to which one offers meat, before he has swallowed it, already secretes abundantly a special gastric juice which makes him capable of receiving and digesting it. All the foods which by their taste please us and dispose us to employ them freely, act in the same way. Thus, we are influenced by the variety of the dishes at meals, the refined culinary preparations, and, in the summary feeding of the poor, by a little wine, spices, alcohol or coffee.

Aromatic or gustatory foods may act as aliments of economy by diminishing the nutritive changes and by moderating disintegration. All aromatic principles, indeed, and ordinary alcohol itself, tend to reduce the changes which are produced in our tissues, and the excretion of urinary nitrogen. But they diminish proportionally the oxygen consumed, the carbonic acid exhaled, and reduce the temperature of the subject. The aromatic medicamental or alimentary principles definitely moderate the vital action after having sometimes raised it by means of reflex actions which they provoke at the beginning. But in these cases, to this sparing or diminution of dissimilation there is no

corresponding proportional profit in the yield in caloric or mechanical energy of the animal machine. Here therefore we have not real aliments of economy.

It has been suggested that the aliments called nervines diminish the proportion of the expenditure which functioning calls forth. There may be produced, indeed, under the influence of these agents a better general use of the alimentary ration ; but experience has shown that these exciting substances do neither prolong nor preserve the life of the animals, still less increase their weight, when, while being insufficiently nourished, these excitants are added to their daily ration.

Is it possible, at least by their means, to maintain normally functions with a less expenditure of proteid materials, reserving the right of replacing the proportion of albuminoid substances thus saved by an isodynamic quantity of fats, sugar or starch ? In a word, can we, by means of nervine aliments, diminish the wear and tear of the animal machine and consequently the daily need of the proteid matters ? This hypothesis seems to be in certain cases conformable with facts : Börker has found that in the case of individuals doing an unvaried work, the addition of coffee to the alimentation increased the volume of the urines in diminishing the excretion of the urea and that of phosphoric acid, whilst allowing of the preservation of health, weight and the strength of the subject. With a daily ration where the nitrogenized aliments are extremely reduced, there are populations of South America, Africa and the islands of the Indian Ocean, where these nervine aliments are consumed in abundance, and who can produce a considerable aggregate of daily work. The strongly spiced rice of the Malays or Japanese, the couscous of the Arab washed down by many cups of coffee, the bread rubbed with garlic or the chocolate of the Spaniard ; the spiced tapioca and the rum of the mulatto and of the black, enable them to resist fatigues which in the case of one of our ordinary workmen, would necessitate an important addition of meat.

Over and above the economic and physiological question, one also understands the importance which this question of economy of proteid aliments would have in the alimentation of invalids amongst whom it is desirable to reduce to a minimum the nitrogenized excretions, toxins and uratic deposits.

Besides we have already seen that the fats, sugars and starchy matters are certainly "sparing" aliments of the proteid compounds, since they diminish in a certain degree the urinary excretion of nitrogen and the expenditure of the system in albuminoids, provided that these ternary bodies are assimilable and in excess in the alimentary ration. It has also been said that gelatinous matters prevent the rapid dissimilation of the

nitrogenized bodies provoked by the tuberculous virus; thyroidin, phosphorus, etc.

M. A. Javal has shown that the addition of a feeble quantity of salt to our aliments very sensibly diminishes the urinary losses of nitrogen, and augments the nitrogenous coefficient, the organism maintaining itself under this influence in health and in weight with an alimentation containing less albuminoids. Here is then *the rôle par excellence* of the "sparing" aliment. In the order of medicines, the arsenicals (especially organic) act in small doses in the same direction, reducing for a given alimentation the losses in nitrogen as well as the pulmonary exhalations of carbonic acid (A. Robin, A. Gautier). Like coffee, tea and alcohol, these agents form effective protectors against exaggerated wear of the animal machinery, the functioning and yield of which they appear to expedite and benefit.

Nervine Aliments.

We shall divide the nervine aliments into: (a) *aromatic aliments* (coffee, tea, cocoa, etc.); (b) *alcoholic liquors* (wine, beer, cider . . . alcohol, etc.); and (c) *condiments* (spices, vinegar, etc.).

Aromatic Aliments.

Under this head we shall study coffee, tea, cocoa, kola, mate, guarana.

These aliments should all be examined together owing to there similar physiological effects and their composition. They all contain the alkaloids of the puric family, that is to say being allied to xanthin and uric acid, to wit, caffein or thein $C^8H^{10}N^4O^2$ (or 1,3,7-*trimethylxanthin*); one finds it in coffee, tea, kola, guarana, mate, cocoa; theophyllin $C^7H^8N^4O^2$ (or 1, 3-*dimethylxanthin*), alkaloid of tea; *theobromine* (3,7-*dimethylxanthin*), an isomeric of the preceding; it exists in cocoa together with caffein, etc. These bases are not however the absolutely indispensable agents of the activity of these substances: as Hoeckel has shown in the case of kola, the powder of this fruit preserves in a large measure its exciting action upon muscles even when one has completely deprived it of caffein by chloroform, and with an equal quantity of caffein this latter acts much less actively in preventing fatigue, when it is administered alone, than when it is given under the form of coffee, tea or kola.

Coffee.—Coffee, which graces the meal of the rich and facilitates its digestion, completes and sometimes replaces that of the poor. Since the seventeenth century, when the Dutch transported coffee from its original countries Arabia, Upper Egypt and the South of Abyssinia, into their colonies of Java and Batavia, then into Europe, the use of coffee has spread over the entire world. European consumption has increased unceasingly; in 1888 it was more than 350,000,000 kgs. of coffee in berries, of

which 48,000,000 were for England, 102,000,000 for Germany and 67,000,000 for France. In France it is six times greater than in 1830.

The coffee plant (*Cofea arabica*) of the Rubiaceæ, is an evergreen shrub, with opposite leaves; they bear at their axil berry-shaped and elongated red fruits, containing two seeds, convex on one side, flat on the other with a longitudinal ridge. These berries are separated from the endocarp, washed and dried in the sun. Thus treated, these seeds form the coffee berries or green coffee. It is of a hard consistency, almost tasteless. But after roasting to 230 to 250° it yields a perfumed powder of which infusion in warm water constitutes the aromatic drink as it is now consumed.

There are many varieties of coffee (Mocha, Bourbon, Martinique, Iquique, Hayti, Java, Ceylon, etc.). The most esteemed is Mocha, which comes to us from Arabia and particularly from Yemen; its berry is small, yellowish and irregular, sometimes almost round. After slightly heating its aroma is fragrant. The berry of the Bourbon coffee is larger, less round and yellowish. The Martinique coffee, very rich in active principles, is formed of voluminous berries, greenish, with a very open ridge. It is a good kind.

Green coffee, that is to say unroasted, has been the subject of much investigation: we know that it contains from 11 to 12·5 per cent. of water and nearly 33 per cent. of cellulose, 12 to 14 per cent. of fatty matters, 13 to 14 per cent. of nitrogenous matters, about 10 of which are a kind of legumin; some sugars and dextrines; traces of a fragrant oil; 3 to 4 per cent. of mineral matters; finally, 0·9 to 2 per cent. of caffein, a very feeble base, partly free, and partly combined with a special tannic acid, chlorogenic or caffeotannic acid.

Caffein is the best known of the active principles of this seed. Roasting does not appreciably modify it. This substance is found again in the infusion of coffee.

It acts on the brain and does away with the tiredness and breathlessness which follow active work or a too quick walk (Lapicque and Parisot, Stewart).

Caffein increases the central temperature and diminishes the peripheral temperature of animals (Leblond). In moderate doses it stimulates the heart's action, upon which it acts as a tonic and causes the arterial pressure to rise by contraction of the little peripheral vessels. It excites the central activity. In stronger doses it depresses the nervous system and cerebral centres, increases the excitability of the muscles, facilitates their activity and causes a part of the sensation of fatigue to disappear. M. Mosso has shown that, under its influence, the work of the first hour may be quadrupled.

Caffein does not appear to sensibly modify the elimination of the daily chlorine and urinary urea, but it induces the production of psychic or mechanical work, which becomes greater with the same alimentation.

Caffeotannic acid[1] (or *chlorogenic* of Payen) with which the caffein is partially united in the coffee is, split up under the action of the dilute alkalies, into caffeic acid and mannitane :

$$C^{15}H^{18}O^{8} + H^{2}O \;=\; C^{9}H^{8}O^{4} + C^{6}H^{12}O^{5}$$

A. Caffeo-tannic. A. Caffeic. Mannitane.

Caffeic acid is itself a dioxycinnamic acid.

$$(C^{6}H^{3})(OH)^{4}(OH)^{3}(CH=CH - CO^{2}H)^{1}$$

Caffeo-tannic acid is slightly antiseptic, like the infusion of coffee itself.

The oleaginous substances of the coffee are partly composed of olein, partly of aromatic matters with a perfumed odour, and partly of a kind of wax.

During heating, towards 230 to 250°, caffeo-tannic acid partially splits up, becomes coloured and swollen in setting at liberty a part of the caffein to which it was united. The cellulose and soluble carbo-hydrates experience a slight caramelization ; the sugars disappear or become changed ; carbonic acid and carbon monoxide are set free ; essences develop at the expense of the destruction of the soluble principles, and dissolve in the oily bodies which impregnate the caramelized mass.[2]

Among the fragrant pyrogenic principles appears caffeol $C^{8}H^{10}O^{2}$, an essence with the odour of coffee, boiling at 196°, capable of being split up by potash by giving salicylic acid.

Green coffee loses by roasting from 12 to 20 per cent. of its weight.[3]

Here is its average composition compared with that of roasted coffee, according to J. Koenig (*loc. cit.* p. 1,002) :—

	Green Coffee.	Roasted Coffee.
Water	11·23	1·15
Nitrogenous matters	12·07	13·98
Caffein	1·21	1·24
Fatty matters	12·27	14·48
Gums and sugars	8·55	0·66
Caffeo-tannic acid	33·79	45·09
Cellulose	18·17	19·89
Mineral matter	3·92	4·75

1 This acid gives a marked green colour to the salts of iron.

2 Exposed to light and air, heated coffee loses a part of these essences. To prevent this, a little powdered sugar (20 grms. per kg.) is sometimes thrown on the coffee beans towards the end of torrefaction. It then becomes enveloped in caramel and preserves its perfume better.

3 Green coffee previously exhausted of water no longer gives any aromatic or bitter principles when it is roasted.

The mineral matters of coffee have, according to Palm, the following percentage composition :—
K^2O = 62·47 ; MgO = 9·69 ; CaO = 6·28 ; Si = 0·54 ; CO^2 = 15·27 ; P^2O^5 = 13·29 ; Fe^2O^3 = 0·65 ; Cl = 0·61.

One hundred grms. of roasted coffee yield to boiling water about a quarter of their weight of soluble matters. Here is the average composition of this liquid so widespread to-day. I have calculated it here for 100 grms. of coffee and also for 15 grms. only, the quantity usually employed to obtain a cup of good coffee of 80 to 100 cc.

	For an infusion of 100 grms. of Roasted Coffee.	For an infusion of 15 grms. of Coffee (or 1 Cup of strong Coffee).
Nitrogenous matters	3·12	0·47
(Of which : caffein)	1·74	0·26
Oils	5·18	0·78
Non-nitrogenous organic matters .	13·14	1·97
Ash	4·05	0·61
Total	25·50	3·82

In 100 parts of ashes of a decoction of coffee, Lehmann has found 51·5 of K^2O ; 3·6 of CaO ; 8·67 of MgO ; 0·25 of Fe^2O^3 ; 10 of P^2O^5 ; 4·01 of SO^3 ; 20·5 of CO^2 ; 1·98 of KCl. No soda or manganese.

We have said before what we think of the action of coffee and what is known of the effects of its most important principle, caffein. It is not only shown that coffee acts like a real aliment of economy, but it seems to allow, for a like alimentation, the production of more work or the same work with less fatigue. It quickens, without doubt, the circulation of the blood and thus ridding the muscles of their waste products, it increases their energy, while at the same time it diminishes muscular and cerebral fatigue.[1]

Coffee helps many people to digest milk. The stimulating power ranks to a certain extent with that of alcohol, and we may say that in this excellent preparation we possess one of the most efficacious means of contending with alcoholism.

Coffee passes as a digestive, slightly diuretic and a little anti-aphrodisiac. This was at least the firm opinion of Trousseau and

[1] See the researches of M. de Gasparin, *Comptes Rendus*, *Acad. Science*, t. XXX, pp. 397, 729 and t. XXXI, p. 25. According to Börker patients subjected alternately to a diet of coffee voided in twenty-four hours : *In the absence of coffee*, 1,364 cc. of urine, containing 22·2 grms. of urea, 0·578 grms. of uric acid and 1·29 of P^2O^5. *With the use of coffee*, they give, on an average, 1,733 cc. of urine, with 12·58 grms. of urea, 0·402 of uric acid and 0·85 grm. of phosphoric acid. Rabuteau, Schultze and others have also pointed out the diminution of urea under the influence of coffee. But G. Sée and Lapicque thought that there was an increase in the elimination of total nitrogen, and Hoppe Seyler and E. Smith an increase of CO^2 exhaled.

that which J. Boussingault expresses in his *Memoirs* (vol. IV). Its rôle as a proper aliment, is, so to speak, nil.

Coffee, as every one knows, produces a nervous excitement, which, if abused, may lead to insomnia, hallucinations, troubles of the circulation and muscular innervation, to precordial distress and to dyspnœa. One may become caffeic just as one can become alcoholic or a morphia maniac. Some people, nevertheless, do not readily suffer from the abuse of it. But it ought to be especially forbidden to arthritics, to uratics, amongst whom it often causes gravel, to gastralgics, to dyspeptics and to those suffering from Bright's disease.

It is the best antidote to opium and to morphia and to the deadly nightshade. It effectually combats the results of drunkenness and accidents leading to coma.

Tea.—Tea, the infusion of which is to-day drunk more or less everywhere, is constituted by the rolled, dried and slightly torrified leaf of the *Thea sinensis*, a shrub of the family of the Cameliaceæ cultivated in China and Japan from time immemorial.

It appears that the different kinds of tea may be produced by the same vegetable or by varieties very much resembling each other. The various kinds depend especially on the moment when the leaf is gathered and on the treatment to which it is afterwards subjected. Tea gathered in the spring is the most highly esteemed. Green tea is made from the first leaves of the year; it is dried and slightly heated soon after it is gathered. Black tea is submitted to a slight fermentation in a heap before being dried. Then it is heated over again several times upon metal plates.

Whether black or green, teas are subdivided each into numerous varieties: among the black teas *Souchong* and *Pekoe* are very much esteemed. Among the green teas *Hyson*, *Tonkay* and *gunpowder* tea may be quoted.

The consumption of tea in France exceeds annually 450,000 kgs.; it was in 1888 in England more than 100,000,000 kgs., and in Russia more than 9,000,000.

Here are two analyses of teas in ordinary use:—

	Ch. Girard.	J. Koenig (average of all kinds).
Water	11·49	9·51
Nitrogenous matter	21·22	24·50
Thein	1·35	3·58
Essential oil	0·67	0·68
Resines, chlorophyll, fats	3·62	6·39
Gum and dextrin	7·13	6·45
Tannins	12·36	15·65
Pectins	16·75	16·02
Cellulose	20·30	11·58
Ash	5·11	5·65
	100·00	100·00

Green teas are generally more perfumed, more charged with chlorophyll, more tannic, poorer in cellulose, richer in thein than the black. This base often rises in black or green teas to 2 per cent. and can reach in the latter even to 5 per cent. of dried leaf.

In the natural state, as commerce supplies it, tea gives up in hot water from 31 to 44 per cent. of its weight of soluble matters. The infusion is made by pouring about 250 cc. of very hot water upon 5 grms. of tea (for five cups) placed beforehand in a metal or porcelain teapot, throwing away immediately this water which has served only to warm the apparatus, and replacing it by 600 cc. of fresh boiling water. After five or six minutes the infusion (made in a closed pot) is ready to serve.

A cup of tea of 120 cc. does not contain beyond 0·4 grms. of soluble substances and 0·025 of thein; rarely more, even for green teas.

Other active bodies are found in the infusion of tea, known or unknown: a volatile essence of a sweet odour, but which disperses little by little with the steam; xanthin that Baginsky discovered in this infusion, about 1884; hypoxanthin and adenin which Kossel discovered there at the same time as the *theophyllin* $C^7H^8N^4O^2$ (or 1,3-*dimethylxanthin*), a diuretic base, acting slightly on the heart[1]; up to 30 per cent. of a particular tannin (colouring the iron salts green), an acid with which the thein is partly combined; gums; extractive nitrogenous matters little known; resins; finally from 5 to 7 per cent. of mineral matters formed particularly of the phosphate of potash, with lime, magnesia and manganese.

Tea, properly speaking, is no more an aliment than coffee; it is, like the latter, an exciting agent of the digestive functions and the kidneys, atonic of the heart and the muscles by its alkaloids. An infusion of tea conduces to mental and muscular work, accelerates the circulation of the blood, renders active the functions of the skin and the excretion of the urine, and reacts usefully upon the greater part of the other functions.

A slight infusion of tea forms an excellent drink, especially in countries where, as in the centre of Asia, Morocco, etc., the filtration of drinking water is difficult or impossible.

Cocoa and Chocolate.—The cacao nib with which the powdered cocoa and chocolate are made, is obtained from the fruit of the cacoyer (*Theobroma cacao*), of the Malvaceæ, a tree of South

[1] It dissolves cold in 179 grms. of water and at 37° in 85 parts. A gramme dissolves in its weight of cinnamate of soda and seven parts of water. Its excitant and convulsive action on the nervous system is similar to that of caffein. Its diuretic action is considerable; it is given in doses of 20 to 50 centigr. Unfortunately theophyllin sometimes fatigues the stomach and causes sickness.

America. These beans, separated from their pulp and dried, are afterwards handed over for commercial purposes.

Many varieties are distinguishable : that of Caracas is the most valued. The contents of these beans are greyish on the exterior. It has been *terré*, that is to say put into the ground, where it undergoes the commencement of germination or diastasic fermentation, which renders it more assimilable and causes a certain sharpness to disappear. The cocoas of Maragnan, Para and Martinique, with smaller redder grains, have not been so treated.

For the preparation of chocolate, the grains of the cacao are first slightly heated, separated from the shells and seeds, ground and finally worked up with sugar and some aromatics.

Deprived of its waste parts, the bean of the cacao plant presents the following composition :

Water	4·5	to	8
Fatty matters	40	,,	51
Red colouring principles, tannin	2	,,	3
Theobromine	1	,,	3
Starchy matters	3	,,	4
Albuminous matters	11	,,	15
Ash	3	,,	4

In cocoa a trace of asparagin is found and a little bitartrate of potash and a great deal of oxalate of lime. According to Esbach, it contains 4·50 grms. per kg. of the latter.

The ashes have this percentage composition : $P^2O^5 = 39{\cdot}6$; $K^2O = 37{\cdot}14$; $MgO = 15{\cdot}97$; $CaO = 2{\cdot}88$; $SO^3 = 39{\cdot}65$; $Cl = 16{\cdot}6$.

The shells or *grabeaux* and other waste products detached from the grain amount to from 5 to 15 per cent. in the raw bean. According to M. Duclaux a good deal of copper is found there.

Cocoa is not only an aliment ; it is also an exciting and gustatory nervine by reason of its essences which roasting develops, and of its alkaloid, the theobromine $C^7H^8N^4O^2$, homologous with caffein of which the physiological properties are very analogous to those of this latter. By its amylaceous, albuminous and fatty matters, cocoa, and still more chocolate (or cocoa with sugar added to it), constitute a complete food rich in nitrogenous and ternary matters. The albuminous matters form the seventh part of the weight of the bean ; fatty substances nearly half. The butter of cocoa is a mixture of stearin and olein fusible from 27° to 31°; it brittles when cold. Generally it is partially removed in the preparations of powdered cocoa, in order to be able to pulverize the bean finely, and to render the matter more easily diluent in hot water.

The torrefaction of the cocoa bean takes place at 230 to 260°. It modifies very little the centesimal composition of the substance.

I have stated that there is no sensible loss of nitrogen. But the natural sweetened matters undergo a slight caramelization, and the perfume which it develops adds its exciting effect to that of the alkaloid.

We notice in the above analysis, the small quantity of starch or of dextrin in this grain ; infusion of cocoa takes, by the action of iodine, only a feeble reddish violet colouring.

Chocolate is prepared by grinding very finely 4 to 5 parts of sugar with 6 parts of cocoa, and generally adding a little vanilla or cinnamon. The chocolate of inferior quality may contain as much as 65 per cent. of sugar.

It is a very agreeable food but difficult to digest, chiefly owing to the abundance of its fats. On the other hand, its great richness in oxalate contra-indicates it for all those who are exposed to uric or xalic diastases, arthritics, those suffering from rheumatism or gravel, or an excess of HCl in the gastric secretions, and generally people who are no longer very young and who do not take sufficient physical exercise.

Here is, according to the *Documents du laboratoire municipal* of Paris, the analysis of some good French and Spanish chocolates :—

	Choc. Menier.	Colonial Co.	Spanish Choc.
Cane sugar	57·47	56·34	41·40
Cocoa butter	22·20	23·80	29·24
Starch, glucose	1·83	0·97	1·48
Theobromine	1·33	1·43	1·93
Albumin	4·75	4·99	6·25
Gums	1·07	1·14	1·42
Tartaric acid	1·48	1·58	1·98
Tannin and colouring matter	0·20	0·20	0·12
Soluble cellulose	4·70	5·04	6·21
Undetermined matters	1·92	1·66	3·25
Water	1·28	0·98	4·38
Ash	1·75	1·87	2·34

An ordinary cup of about 70 cc. is prepared with 16 grms. of chocolate.

100 grms. of powdered cocoa, freed from fat up to 25 per cent., contain : 1·3 grms. of theobromine, 17 grms. of total nitrogenized substance of which 8 per cent. consist of albumin, 10 to 12 grms. of carbo-hydrates. Ten grms. of this cocoa, sufficient for a small cup, will correspond then to a tenth of the above quantities.

The comforting effect that a cup of cocoa or chocolate containing only 14 grms. of alible matter, of which there are 7 grms. of sugar and 2·5 grms. of fat, *instantly* procures, in extreme fatigue, as I have assured myself, can only be explained by a nervous effect which the odour of cocoa provokes, which the

tonic influence of the theobromine continues and which the nutritive part of the aliment completes in proportion as it is absorbed.

Kola, *Guarana*, *Mate*, *Coca*.—These various products should be added to the preceding on account of their stimulating and tonic effects which they owe in part to the caffein and to other puric bases.

Kola, which among the negroes of Central Africa, fills the part of resisting agent to fatigue, is the seed of the fruit of the *Sterculia acuminata*. Its seeds of yellowish, pink or reddish colour, have the consistency and slightly the form of a very large almond. Some may weigh up to 15 and 20 grms. Analysed in a semi-fresh state, they have given to MM. Heckel and Schlagdenhauffen the following results[1] :—

Water	11·92
Caffein	2·35
Theobromine	0·02
Fatty bodies	0·59
Tannin (0·027 soluble in chloroform)	1·62
Red of kola	1·29
Glucose	2·87
Starch	33·75
Gum	3·04
Colouring matters	2·56
Proteid matters	6·76
Cellulose	29·83
Ash	3·32

This fruit is therefore very rich in caffein. Besides some amylaceous matters which form more than a third of its weight, it contains also some active substances, in particular that denominated in the above analysis *red of kola*. When all the alkaloids have been extracted from the fruit by means of chloroform, kola still enables one to resist hunger and fatigue by virtue of some little known substances.

M. A. Mosso[2] and M. Marie have demonstrated that kola increases the number and energy of the muscular contractions, prevents fatigue and overwork, renders respiration more free and more powerful. It is a heart tonic, also an efficacious agent in neurasthenia. Kola possesses, finally, exciting and aphrodisiac properties. It is employed in cases of intestinal atony, in affections of the liver, etc.

Guarana is a preparation which is made with the flour of the torrefied seeds of the *Paullinia sorbilis* (Hypocastanceæ). Elongated cylindrical loaves which are exposed to smoke are made from it with a little water. Travellers in Brazil use this

[1] *Comptes Rendus*. t. XCIV, p. 802.
[2] *Arch. ital. de biolog.* vol. XIX, fasc. 2.

preparation of guarana mixed in boiling water (punch), sugared or not, to resist hunger and fatigue when on the march.

It is said to be also endowed with antifebrile properties. M. Fournier has found in it some tannate of caffein, a principle particularly soluble in ether, turning it red in the light, some gums, tannin, starch, an aromatic volatile oil, a green oil of sour flavour, etc.

Caffein in guarana amounts to about 4 per cent.

Mate or *Tea of Paraguay* is especially made from the leaf of a shrub, the *Ilex paraguayensis*, which is found in Paraguay, Brazil and in the Argentine Republic. Dried and slightly roasted, these leaves produce a coarse brownish green powder, smelling of tan, and which is used as a kind of tea. Three or four lots of boiling water may be poured on the same leaves. The tonic and stimulating properties of the mate are partly due to the thein, of which it contains 0·5 to 1·8 per cent., and partly to the matetannic acid (20·88 per cent. according to Strauch). Here is the composition of mate according to Peckolt :—

Cellulose, moisture	90·84
Caffein	0·55
Matetannic acid	1·68
Pyromatetannic acid	0·15
Chlorophyll and resin	0·61
Extractives and caramel	1·79
Dextrin, salts	1·82
Brown acid resin	2·55
Volatile oil	Traces.

The infusion of mate is a little bitter, aromatic and astringent. It regulates the evacuations. It is a neuro-muscular excitant.

Coca, made from the leaves of the *Erythroxylon coca* (Rhamnaceæ), is taken as an infusion ; the natives chew these leaves with a small quantity of ash or lime. It produces first a slight excitation, then it causes the sensation of hunger to disappear, but it does not nourish and does not allow of going long without food. Coca especially owes its effects, but not entirely, to its alkaloid *cocaine*. Chewed in a small quantity, the coca leaves sustain the forces for some time and allow fatigue to be borne without recourse to aliments.

Its properties, at once anaesthetic and excitant, contain a number of products, cocaine and other bases, variable according to the species. The coca of Peru gives up to 1 per cent. of cocaine, that of Jamaica only 0·26 per cent.

XXV

FERMENTED BEVERAGES—ALCOHOL—WINE

ALCOHOLIC beverages have been made and consumed from the most remote ages by all people, civilized or savage. The Egyptians, Greeks, Germans and Gauls already knew how to produce fermentation of the grain of cereals, and made thus some kinds of beers or ales. In China, *manduring* and *fan-tsou;* in India *arak;* in Thibet *chong* and in Nubia *bouja* have been made for centuries by causing infusions of rice or other boiled cereals, mixed or not with honey and spices, to ferment.

Palm wine, *pulqué* of Mexico, *cachaca* of Brazil, *guaruzo* of South America, *mobi* of Virginia, etc., are prepared with the sweet sap of the palm, American aloe, sugar cane, and decoctions of rice or potatoes. In Norway the sap of the birch is fermented; in the Alps an infusion of gentian roots; in the North of Europe they have made for a long time and still make *hydromel* from the honey of bees.

Lastly, we know the kephir of the Arabs and the koumiss of the Cossacks obtained from the fermented milk of the camel or mare. There is nothing, even to the *kangangtsyjen*, made by the Tartars with lamb's flesh, mixed with cooked rice and other vegetables, and fermented, which is not used as an alcoholic drink. This universal custom of making and drinking fermented liquids of every kind does not perhaps demonstrate their absolute necessity, but it seems to satisfy a universal, instinctive and powerful need.

The characteristic and common principle of all these fermented drinks is alcohol.

Before studying wine, cider, beer, etc., a question, the solution of which is indispensable, first presents itself, viz., whether this alcohol is a simple nervous exciter, whether it is only a more or less dangerous poison, or if it is at once an excitant, a tonic and an aliment in the true acceptation of the word.

Opinions have long been divided on this subject. They are still so to-day; but it follows definitely from the most irreproachable modern observations and experiences that the alcohol absorbed by animals is almost entirely consumed in the system. Like fat or sugar, it should be considered as an aliment procuring us, as we shall show, the greater part of the energy corresponding to the number of calories which it would produce if it were completely burnt in a calorimeter. Whether the individual works,

or whether he be at rest, we think that we can here show, thanks to the most recent researches, that in the manner of fats and sugars alcohol protects the tissues, and in particular their protoplasmic matters, against the destruction which all vital functioning provokes, but on *the condition nevertheless that it be given without abuse, the latter producing contrary effects.*

Alcohol, in a word, behaves as a true aliment and even as a valuable aliment, as long as it does not exceed 1 grm. per kilogramme weight of the body in the daily allowance, a dose known to be on this side of the dangerous zone, as we shall see.

Liebig had suggested, without other proofs than those of common sense, that alcohol is an aliment analogous to sugar and that it is consumed in the system. "The ingestion of alcohol," he writes, "dispenses with the use of starch or sweetened aliments. . . . It is an exception to the rule that a well nourished individual becomes a drinker of brandy; but when the workman gains less by his work than is needful to him to procure the necessary quantity of aliments, an imperious, inexorable need forces him to have recourse to brandy."[1]

This opinion of Liebig's was generally accepted when, in 1860, Lüdger, then Lallemand and Duroy, and lastly and especially Maurice Perrin tried to show, by a series of important researches, that alcohol does not burn in our organs, that it only passes through the system, fixing itself momentarily in the nerve centres which it excites or intoxicates, to be slowly eliminated afterwards by the skin, lungs, and kidneys, either naturally or at the most, only oxidized in a very small proportion in the state of aldehyde.

Perrin in fact showed that a part of the alcohol is found again in the sweat, urine, expired air, etc., even when it is taken in the form of wine and in a small quantity at a time. (*Comp. Rend. Acad. Sciences*, August 1, 1864). He thought that we could conclude from this that almost all the alcohol is thus eliminated. On the other hand, Prout, Lehmann, Vierordt, E. Smith, etc., have remarked, under the influence of alcohol, a diminution of the expired carbonic acid. This diminution, which varied from 5 to 22 per cent. in the experiments of Maurice Perrin, strengthened the supposition that the alcohol is not consumed in the system. A little later it was recognized that in the case of alcoholics, *moderate doses* of alcohol (1 grm. at the most per kilogramme of weight of the subject) do not modify the quantity of carbonic acid expired and oxygen absorbed; but they only slightly diminish (from 6 to 7 per cent.) the excretion of urea (Fokker[2], Munk[3], Obernier[4],) an excretion which, on the contrary,

[1] *New Letters on Chemistry* (35th letter), French translation.
[2] C Voit, *Handbuch*, p. 170.
[3] *Arch. de Du Bois-Raymond*, 1870, p. 163.
[4] *Pflüger's Arch.*, t. II, p. 503.

increases if the alcoholic dose is doubled or trebled, producing a slight excitation of the nerve centres (Munk, Keller, etc.). Some analogous results were observed concerning the influence of this body on the consumption of fats which it protects against oxidation. In a word, *in small doses*, alcohol behaves as a "sparing" aliment; *in strong doses*, as a noxious substance and destroyer of protoplasm.

But these experiences do not enable us to come to a definite conclusion on the direct part played by this principle as a source of heat and energy in animals, and opinion remains divided: many medical men—Lussana, Lauder-Brunton, Dujardin-Beaumetz, A. Bouchardat, etc., think that alcohol is partially transformed and consumed in the system which profits by the corresponding energy; on the other hand, Hoppe-Seyler, Hermann, Wolfberg, etc., remain convinced that the alcohol passes through the system without being sensibly decomposed in it.

Renewing the study of this question by quantitative methods, Binz appears to have been the first to establish by some precise experiments (1880), that alcohol is almost completely consumed in our tissues. Botländer, Albertoni, Strassmann and Hédon came to the same conclusion. In 1891, Staumreich established that the isodynamic substitution of alcohol for a certain quantity of fat or sugar, in the diet of an individual in nitrogenous equilibrium, causes an increase in the dissimilation of the nitrogen (1 grm. to 1·5 grms. loss per 24 hours); this excess of lost nitrogen continues two or three days after the use of alcohol has been stopped.[1]

R. O. Neumann, in 1899, arrived at some analogous conclusions, as well as Rosemann, to whose works we shall return later.

At Montpellier, M. L. Roos, the learned director of the onœlogic station of Hérault, in 1900, made the following experiment: two lots of guinea-pigs, of the same litter and initial weight, received the same nourishment, but one of the lots was given a daily supplement of 30 cc. of red wine, 9° per cent. per kg. weight of the animal. At the end of three weeks, the guinea-pigs receiving the wine made an advance in weight of 5·6 per cent. on the others; at the end of five months they weighed 12·9 per cent more.

In 1901, M. Chauveau[2] was led to study the effects which result from replacing in the alimentary ration a part of the ternary aliments by alcohol in isodynamic quantity. A dog weighing 20 kgs. received, per 24 hours, 500 grms. of meat and 762 grms. of sugar, and produced a certain amount of work measured by the distance that he traversed in a treadwheel which he caused to turn round. At the same time the gain or loss in weight of the animal was ascertained. These facts being established, a third of the sugar of his allowance was replaced by an isodynamic

[1] *Arch. f. Hygiene*, t. XXXVI, p. 1, 1889; *Inaugur. Dissert.*, Berlin, 1891.
[2] *Comptes Rend. Acad. sciences*, t. CXXXII, pp. 65, 110.

weight of alcohol, say 49 grms. per 24 hours[1], the work that the animal produced and also its weight, were measured. Under these conditions, alcohol in isodynamic weight always proves itself to be inferior to sugar. The dog without alcohol traversed 10 kilometres in his wheel per hour, the dog with alcohol 7 kilometres only. M. Chauveau concludes (*loc. cit.*, p. 114) :—"The partial substitution of alcohol for sugar in isodynamic proportion in the alimentary ration of a subject who works, entails : 1st, the diminution of the absolute value of muscular work ; 2nd, stagnation or diminution of the maintenance (in weight) of the animal." But, *à propos* of these last experiments, I will remark that he experimented on dogs unaccustomed to a nourishment as different to their natural nourishment as alcohol was, and of which they received the considerable dose of 49 grms. per 24 hours for 20 kgs. of animal. This weight would correspond proportionally for an average man of 66 kgs. to 2 litres of wine at 9·5 or to 152 grms. of absolute alcohol, or to 380 cc. of ordinary cognac at 50 per cent. One could not but doubt that this quantity of spirituous liquor absorbed by a workman, accustomed or not to alcoholic liquors, would interfere with his nutrition and diminish his yield in work.

In 1902, fresh experiments entirely convincing were carried out at Washington on this important and delicate question by Messrs. Atwater and Benedict.[2] They first established for each of them a diet suitable for keeping their weight and the heat they threw off, constant. This was carried out by enclosing the experimenter himself for several consecutive days in the respiratory calorimeter already described (p. 63). Each of the subjects experimented upon, first put into equilibrium of weight as regards nitrogenous loss and heat emission, was introduced into the calorimeter, and the total amount of energy which he produced and the other constants of his state, were measured in the form of heat. Afterwards a certain quantity of alcohol (the value of a litre of wine per 24 hours) was substituted in his diet for a period of three or four days, for a calorimetrically equivalent quantity of sugar or starchy material, and the calories produced were measured again. As a check, the subject returned for the following three or four days to the original diet *without alcohol*, and the same readings were again taken. It was thus experimentally established to almost a *thousandth part*, that *the quantities of heat produced were identical either when alcohol was isodynamically substituted in the diet,*

[1] M. Chauveau has even given as much as 84 grms. of pure alcohol to a dog weighing 20 kg.

[2] *Experiments on the Metabolism of Matter and Energy in the Human Body*, Bulletin, No. 69, U.S. Depart. of Agriculture ; office of experiment, Washington Station, 1899, and *Mém. de l'Acad. nationale des sciences*, t. VIII, Washington, 1902. (See a resumé of these researches in the *Annales Institut Pasteur*, 1902, p. 857.)

or when the subject did not take any alcohol but received in its place a proportional quantity of sugar or starch.

The two experimenters examined afterwards the influence of alcohol on work. They effected this by means of a motor cycle, united to an ergometer, enclosed in the calorimetric chamber. We have said (p. 66) that a dynamo transformed the work produced into electricity, and that this was changed into equivalent heat in traversing an Edison lamp. Finally, all the work, that of friction included, was then transformed, in the chamber itself, into heat that was measured either during the ordinary alimentary diet, without alcohol, or during the period of isodynamous substitution of alcohol for a part of the aliments. The heat collected in the calorimeter, during work, still remained the same *either when the alcohol was substituted or when it was not.* Here are some numerical results :—

EXPERIMENTS OF ATWATER AND BENEDICT ON THE ISODYNAMIC SUBSTITUTION OF ALCOHOL IN DIET.

Duration.	Diet.	Quantities.	Calories produced.
1st. *In a State of Rest.*			
I. 3 days .	*a.* Albuminoids	124 grms.	—
(Subject A.)	Ternary bodies (fats, sugar, starch) (no alcohol)	*sufficient quan.*[1]	3061
3 days . .	*b.* Albuminoids same as in *a* . .	124 grms.	—
(Subject A.)	Ternary bodies as in *a*, but with partial isodynamic substitution of *alcohol*	124 grms.	3044
II. 3 days .	*c.* Albuminoids	100 grms.	
(Subject B.)	Ternary bodies	*sufficient quan.*	2490
,,	*d.* Albuminoids as in *c*	100 grms.	
	Ternary bodies as in *c*, but with isodynamic substitution of : *alcohol*	99 grms.	2491
,,	*e.* The same alimentation as in *c* .	—	2489
2nd. *In a State of Work.*			
III. 4 days .	*f.* Ordinary diet without alcohol		
(Subject A.)	with : albuminoids	124 grms.	3862
,,	*g.* Same diet as in *f* with isodynamic substitution of : *alcohol*	121 grms.	3891
IV. 3 days .	*h.* Ordinary diet without alcohol		
(Subject B.)	with : albuminoids	100 grms.	3487
,,	*i.* The preceding ordinary diet, but with isodynamic substitution for the ternary bodies of : *alcohol*	99 grms.	3458
,,	*k.* Return to diet *h*	—	3495

[1] A *sufficient quantity*, that is to say a quantity sufficient to enable this diet to give the number of calories indicated (here : 3,061). In the period " b " a part of the sugars or starch of the period " a " is replaced by alco-

In these experiments the work consisted of six to eight hours per day on the motor cycle.

It can be seen from the figures in this table, that the work accomplished for a given weight of alcohol replacing an isodynamic quantity of sugar or fat, was identical in the two cases (with or without alcohol) since the quantity of heat proportional to this work transformed into caloric by means of the dynamo remained exactly the same. This result is especially interesting as one of the experimenters was not accustomed to drink alcoholic liquors.

On the other hand, from the point of view of the general nutrition and in particular of the losses or gains of the body in nitrogen, the results of these important researches were as follows :—

	Nitrogen lost or gained in 24 hours by the subject under experiment.
Period of repose without alcohol	-0.70 grms.
" " "	0.00 "
" " "	-0.60 "
Period of work	$+1.1$ "
Period of repose with alcohol	-1.9 "
" " "	-1.1 "

There is then, under the influence of the substitution in isodynamic quantities of alcohol for fats and sugars, a slight increase in the nitrogenous excretion. The machine is very slightly more used up with alcohol than with sugar.

This same conclusion is arrived at from the important work of R. Rosemann.[1] The subject was first put into a state of nitrogenous equilibrium by means of a previous carefully studied alimentation, then a certain quantity of alcohol was isodynamically substituted for an equivalent proportion of sugar or fat. Here are the results obtained in the two cases of normal and insufficient nourishment :—

First Series of Experiments : Alimentation in Nitrogenous Equilibrium.

	Duration.	Alcohol expressed in Wine per day.	Daily loss or gain in Nitrogen.
1st. *Preparatory period*	9 days	0·0	+1·1370
2nd. *Period of alcohol* (60 grms. of bread and 75 grms. of sugar replaced by alcohol)	14 days	1400 cc.	+0·7960
3rd. *Period of return* (return to the alimentation of the first period).	6 days	0·0	+1·0487
4th. *Period of control* (suppression of the same aliments as in 2nd period, but without replacing them by alcohol)	7 days	0·0	−1·4613

hol in isodynamic quantity, which would be in this case 124 grms., during the three days of this period "b."

[1] *Arch. f. ges. Physiolog.*, Bd. LXXXVI, p. 307 (1910), *Der Einfluss der Alkohols auf den Eiweissstoffwechsel.*

Thus, according to these experiments, alcohol is opposed to the dissimilation of the albuminoids (0·7960 grms. fixed per day, instead of 1·4613 grms. lost when alcohol was not added); but it is less efficacious than an isodynamic quantity of carbo-hydrates (0·7960 grms. of nitrogen fixed per day, when pure alcohol was substituted, instead of 1·1370 with the ordinary aliments).

SECOND SERIES OF EXPERIMENTS: NOURISHMENT INSUFFICIENT IN NITROGEN.

	Duration.	Alcohol expressed in Wine per day.	Loss or gain in Nitrogen per day.[1]
1st. *Preparatory period*	9 days	0·00	–0·8883
2nd. *Period of alcohol* (20 grms. of sugar and 100 grms. of bread isodynamically replaced by alcohol)	10 days	1400 cc.	–1·3389
3rd. *Period of return to sugar* (wine replaced by 220 grms. of sugar)	5 days	0·00	–0·3724
4th. *Period of control* (alimentation of the 2nd period less wine)	4 days	0·00	–2·3728

Alcohol has then a preserving action on the albuminoids, as the nourishment in nitrogen is or is not insufficient; but, in the two cases, this action is a little less powerful than that of an isodynamic quantity of sugar, fats or starchy substances.[2]

On the other hand, it has been shown (Experiments of Atwater and Benedict) that alcohol is suited to replace isodynamic weights of starch or sugar, but on this condition, that it does not exceed a certain limit, which is about 1·2 to 1·3 per kg. of the weight of the body and per day.

We see then how little foundation there was for the opinion of Maurice Perrin, Lallemand and Duroy, Hoppe-Seyler, Brücke, Wolfberg, Chauveau, Bunge, Ch. Richet, etc., that alcohol cannot be considered as a true aliment, and that it cannot furnish its equivalent of functional energy.[3]

[1] They analysed all the aliments and considered as gained or lost the difference between the alimentary nitrogen and the total nitrogen of the excretions.

[2] These results are analogous to those obtained by Mogiliansky. (*Der Einfluss der Alkohols auf die Assimilation und den Stoffwechsel der Stickstoffes an die Assimilation der Fette*, Inaug. Wissench. St. Petersburg, 1889.) In these trials made on some subjects receiving a superabundant alimentation and whenever they wished it, alcohol increased the assimilation, or rather kept down the dissimilation. They do not agree with those of Miura (*Zeitsch. f. klin. Med.*, vol. XX, 1892), who experimented exactly as Rosemann did, and who found that in replacing isodynamically in alimentation 110 grms. of carbo-hydrates by alcohol, or in suppressing this alcohol, the loss of the organism in nitrogen remained the same.

[3] Bunge expresses himself thus: "It has been recognized that alcohol is consumed (by animals) . . . Alcohol is then without doubt a source

The only conclusion which results from the experiments of these authors is that in the case of man, in doses greater than 1·5 grms. per day and per kg., alcohol should be considered as dangerous. But in moderate doses, and in these doses only, it forms an aliment suitable to quickly procure heat and vigour, *to warm up the blood*, as is the common expression, to protect the nitrogenous part of our tissues, *and finally to place the subject in a state to be capable of suddenly furnishing an effort superior to that which alimentation without alcohol enabled him to make.* The employment of this body does not answer then to an artificial need, it is an aliment of immediate action, a momentary resource, although dangerous in its handling, for the insufficiently nourished individual. Alcohol is at the same time a combustible and powerful nervous stimulant. Absorbed, even in small doses, it passes into the plasmas and is fixed in the nerve centres, from which it is afterwards only slowly eliminated (Nicloux). Useful, sometimes valuable, as long as it is used in moderation, this excitation becomes disastrous if there is a repeated abuse of alcohol. But the deplorable consequences of this abuse, to which we shall return later (p. 308), ought not to make us reject this valuable addition to alimentation, any more than the abuse of morphia should make us abandon the use of this admirable drug.

The universal employment of fermented beverages is therefore logical and well founded. It shows that the good sense of ordinary people may sometimes be rightly opposed to the too exclusive theories of a science which formed, and, in this particular case,

of living force for our bodies; but this does not mean that it is a food. In order to justify this conception it would be necessary to prove that this living force set free by its combustion, is employed in the accomplishment of a normal function. The combustion of alcohol ought to spare that of other aliments. But we cannot concede that either." (*Ann. de chim. biolog.*, p. 124, 2nd German edition.)

M. Chauveau (*Discours à la Soc. nationale d'Agriculture*, December 11, 1901, p. 10) writes: "I am not then an enemy to wine . . . But is it a food? Is it a simple drink? A food! To deserve this name it would be necessary that the potential energy that wine includes, under the form of alcohol and organic acids, should be incorporated in our system. But it is nothing of the kind. . . . These (the alcoholics) are in a manner the succedanea of true aliments. It is doubtful if they are ever employed by the organism for the execution of its physiological activities. Even if they did so, they would remain always vis-à-vis to the true potential furnished by the carbo-hydrates, in a state of pitiable inferiority."

I recall here that traces of alcohol have been pointed out in the milk and urine, and that Professors Stoklaza and Czerny (of Vienna) have stated that they "have found in our tissues an alcoolase which changes the sugar into alcohol, like the alcoolase of Büchner. It is then very probable that alcohol can be produced in our tissues, or be one of the necessary derivatives of their dissimilation." (*Bull. soc. chim.*, 3rd. S. vol. XXX, p. 339.)

especially prejudiced, by the terrible evil of alcoholism, has long remained more utilitarian and persuaded, than experimental and confident.

Used without abuse, fermented beverages agree with all those who find in too poor an alimentation only an insufficient recuperation: with the adult who works hard and is badly fed, with the convalescent who is recovering, with the old man who is decaying, and with the workman and sailor who have need of warmth. The use of wine and beer is a protection against the abuse of spirits. But generous wines, and alcohol itself, are especially valuable in cold, damp and marshy countries. Again it is well to know the danger to which the use of these liquors which we are often tempted to abuse, exposes us. We shall revert to this important point in the chapter devoted to alcoholism (p. 307).

Wine.

Vegetable palæontology has established that the vine existed already in Asia, Africa and Southern Europe at the remote period of the tertiary age. Man found it there in the wild state; he has collected, cultivated and modified it, he has produced innumerable varieties or species of vines. To-day the vine covers a fifteenth part of the land in France. It employs a sixth of the population. France annually gathers, on an average, 50,000,000 hectolitres of wine. Spread over a population of 35,000,000 if all the French wine were consumed there, there would be 132 litres per head per annum, or 362 centilitres per day. In reality, statistics showed that, in the towns, the consumption of wine is 380 centilitres, or a little more than a third of a litre, per head per day, and a good deal less in the country.

These figures show that if the danger of alcoholism exists in France, as everywhere in Europe, it is due not to the consumption of wine but to its very slight use, the tendency of the workmen for some years being to replace wine and beer, which only give the effects more slowly, by alcohol in its natural state, which has a stronger taste and which seems to bring him immediate comfort.

Wine is the result of the alcoholic fermentation of the juice of the fresh grape arrived at maturity. It is an eminently complex liquid, varying according to the kind of vine, origin, year and the care which it has received, but always containing a set of principles which characterize it. These are, with water which forms 70 to 90 per cent. of it, vinous alcohol accompanied by a small proportion of homologous alcohols, propylic, butylic and especially amylic; a very small quantity of ethers with a vinous or aromatic odour; some glycerine; sometimes a little mannite, inosit, glucose and levulose; a trace of aldehyde, some

pectic matters, gums and dextrins ; a very small quantity of fatty and albuminous substances ; some acids partly free and partly combined : acetic acid, propionic acid, malic, citric, succinic, butyric, lactic and especially tartaric, the last in the form of acid tartrate of potash. Wine contains besides, some colouring, astringent and tannic substances, most often in the form of ferric salts ; some essences with an odour of fruits and vanilla ; various salts in which predominate potash, with a little lime, magnesia and alumin ; some phosphates, sulphates, chlorides, etc., and lastly some gases, carbonic acid and nitrogen.

Of all these bodies water, ordinary alcohol, colouring matters, tartar, glycerine and sugar (the latter in the case of sweet wines, that is to say wines which have not completely fermented) are the most important by reason of their rôle and bulk.[1]

The weight of water varies in ordinary wines (sweet wines excepted) from 718 to 935 grms. per litre, that of alcohol from 45 to 135 grms., that of glycerine from 4 to 13 grms., that of colouring matters from 0·6 to 2 grms. and more in red wines, that of tartrates from 1 to 3·75 grms. The whole of all the other substances—only reaches 9 to 13 grms. per litre. It is these, however, which distinguish the different growths, which communicate to the wines their bouquet, vinous quality and special taste. The indefinite variations of these matters and their combinations which time slowly completes, make of some of these wines inimitable beverages of an exquisite aroma and taste, differing with each wine and each growth.

As we have already said, wine in moderate doses is a restorative aliment, a hygienic drink, a nerve exciter, qualities that it owes to its alcohol, its bouquet, to the *ensemble* of the materials which constitute it.

Wines contain especially alcohol accompanied by ethers, essences and fixed substances. These last remain when these liquids are distilled. They form their *dry extract*, the weight of which varies from 14 to 90 grms. per litre. As a rule it is not less, for red wines, than four and a half times the weight of alcohol corresponding to this same volume of liquid. But still there are some wines which leave only 10 to 12 grms. of dry extract and others which furnish as much as 190 grms. per litre ; but the first

[1] By causing to ferment 100 kgs. of white sugar with the lees of white wines of Charente, MM. Claudon and Morin have obtained 50 kgs. of vinous alcohol, a little aldehyde, 158 grms. of isobutylenic alcohol, 2,120 grms. of glycerine, 205 grms. of acetic acid, 452 grms. of succinic acid and 207 grms. of *oils*. The latter were formed of 145 grms. of ordinary alcohol, 2 grms. of normal propylinic alcohol, 1 grm. of isobutylic alcohol and 50 grms. of amylic alcohol. Several of these products, the last in particular, are poisonous. They are mixed naturally *in a very small proportion* with ordinary alcohol, or with cognac extracted by the distillation of fermented liquids.

more often come from mediocre and imperfectly ripened grapes; the others are, on the contrary, *sweet wines* in which the sugar of the must originally exceeded, before fermentation, the weight of 200 to 220 grms. per litre; or else these are wines in which *sulphur has been put* in which the sugar has been kept by an addition of alcohols, sulphurous acid, bisulphites, etc., substances which have paralyzed the action of the ferments. In general, the best red wines of our temperate countries (Burgundy, Bordelais, of the South) give from 16 to 26 grms. of dry extract per litre.

Half of this dry residue is made up of glycerine, tartar, colouring matters and a few mineral salts. The other half comprises dextrins, sugars, colouring or non-colouring tannins, aromatic principles, organic acid salts (succinic, citric, malic, tartaric), pectic matters and albuminoids, and finally some unknown principles.

Alcohols enter into the constitution of wines to the extent of 45 to 132 thousandths of their weight. They are almost solely represented by ethylic alcohol. Of the total weight of these alcohols, propylic alcohol forms at the most a thousandth part, butylic alcohol five thousandths, amylic alcohol 2·5 thousandths, but these proportions may be very variable.

Wines, which like Madeira, Marsala and port contain more than 140 grms. of alcohol per litre, that is to say which show more than 17·5 degrees per cent. in the alcoholmeter, are alcoholized wines. Those which give less than 50 grms. of alcohol to the litre, or which show less than 6·2 degrees per cent. in the alcoholmeter, are wines too light, generally too *green* (that is to say, coming from badly ripened grapes) or else wines which have had water or sour wine added to them. However, some good wines of the South, of the Centre, of Burgundy, Bordelais, Alsace and Hungary can scarcely show 7 to 8 in the alcoholmeter.

We have not to describe here ethylic alcohol itself. It will suffice that in the form of absolute alcohol it forms a spirituous, inflammable liquid boiling at 78·4°, of a density of 0·795 at 15°, gradually oxidizing in air, especially under the action of porous bodies or certain ferments, and gives aldehyde and acetic acid. We know that it produces drunkenness in man and animals when it is drunk to excess.

Glycerine was discovered in wines by Pasteur. They contain from 4 to 13 grms. per litre; even as much as 17 grms. per litre of it may be found in certain wines of Southern countries. This substance may be accompanied by mannite (wines of Bordeaux, Algeria), glycols, levulose, and perhaps erythrite.

All these principles mixed with alcohol and succinic acid, contribute towards the *vinous* savour of the liquid.

In the sweet wines, or *vins de liqueur*, in those called *white wines* made with a grape ripened on a screen before fermentation (white wines of Bordeaux, Rhenish wine), and in wines made from

dried grapes, some levulose may still be found in a very sensible quantity (50 to 60 grms. and more per litre) mixed or not with glucose. These are as many nutritive elements which cannot be neglected.

Sweet wines, whether they come from grapes originally very rich in sugar, or whether they have been sweetened afterwards, like champagne, or whether they are the result of sulphured musts, that is to say the fermentation of which has been stopped before the sugar has completely disappeared, by the addition of an antiseptic such as sulphurous acid or alcohol, all these wines contain glucose and levulose in very variable quantities, being able to reach, as in certain Malagas, 150 grms. per litre.

The organic acids, partly free or partly combined with mineral bases, partly etherized by alcohols, contribute to the flavour and bouquet of the wines. The most abundant, tartaric acid, is united almost entirely to potassium in the form of bitartrate of potash $C^4H^5KO^6$. The acidity which this salt brings, varies in wines from one to two-thirds of the total fixed acidity, which is from 4 to 8 grms. per litre (expressed in SO^4H^2) for young wines. When they become old, this acidity diminishes and falls to 4 grms., and even 1·5 grms. in the good French wines.

Succinic acid is met with in all wines. In those from France, we find from 0·9 grms. to 1·5 grms. per litre with a little malic acid and perhaps citric acid.

Lastly, the red wines may contain as much as 2 grms. per litre of œnotannic acid; the white, only a trace. It is a special tannin which contributes to the preservation of wine. It gives with ferric salts a dark green precipitate soluble in the gastric juice.

Amongst the volatile acids, we find in wines scarcely any (0·150 grms. to 0·250 grms. per litre) acetic acid, with a trace of propionic, butyric and valeric acids (Ordonneau, Winckler).

The bouquet of wines is only due in part to the whole of the ethers slowly formed by the union of the alcohols with the remaining free acids of the fermented liquid.

M. Berthelot by drying wines with ordinary ether in a non-oxidizing atmosphere, has extracted from them the *perfume*. Its weight rose to about a thousandth part of that of the liquid. Of a fragrant odour for famous wines, this perfume is formed of amylic alcohol, of an essential oil in part mixed with true ethers, and a neutral principle appearing to belong to a group of very oxygenated aldehydes and forming the true *bouquet essence*. We know to-day that the materials which thus co-operate to give wines their very special aroma, are especially secreted by yeasts, the varieties of which differ according to the crus and vines.

I have shown that the colouring substances of the red wines are not, as was formerly thought, one and the same material—

œnoline—but that they differ with each variety of vine. However they all belong to the same family of complex tannins characterized by their divisions, under the influence of melting potash, into phloroglucine and caffeic or hydroprotocatechic acids and a derivation of them, generally acrylic. These red pigments are substances with an astrigent taste, of an extreme oxidability in the presence of air and alkalies, colouring lead acetate violet, blue or dark green.

The following is the composition that I have found for a few of them :—

For *Gamay* . . .	$C^{20}H^{20}O^{10}$	For *Grenache* . . .	$C^{23}H^{22}O^{10}$
„ *Carignan* . . .	$C^{21}H^{20}O^{10}$	„ *Aramon* . . .	$C^{23}H^{18}O^{10}$
		etc.	etc.

There are also nitrogenous matters in them, the amidogen NH^2, partially replacing there the hydroxyl OH.

The salts with mineral acids contained in wines are the phosphates of potassium, lime, magnesia and of iron, chloride of potassium, etc. The sulphuric acid of the natural sulphates varies in wine from 0·109 to 0·308 grms. per litre ; the phosphoric acid from 0·15 grms. to 0·50 grms. ; iron from 0·008 grms. to 0·050 grms. per litre. We see that wine is not a negligible source of iron for the organism.

To sum up, a litre of average wine contains the following proportions of the principal materials fit to provide us with energy by their combustion :—

	Average.	Corresponding calories.
Alcohol	80 grms.	566[1]
Glycerine	6 „	25·8
Reducing sugars, mannite, glycol .	1·5 „	6·0
Gum, dextrin, etc.	1·0 „	4·2
Cream of tartar	2·0 „	4·1
		606

The combustion of the organic principles of a litre of average wine corresponds then to about 600 Calories.

Now I will give you some average analyses of the most ordinary wines. In the following table alcohol is indicated in percentage degrees, which, multiplied by eight, would give in grammes the weight of this principle per litre.

[1] Reckoning that four-fifths alone of the alcohol are utilized.

COMPOSITION (RELATING TO THE LITRE) OF DIFFERENT FRENCH AND FOREIGN WINES.

	Alcohol in Centesimal degrees.	Dry Extract at 100°	Glycerine.	Tartar.	Total acidity expressed in SO^4H^2.	Ash.	Reducing matter reacting with Trommer's Test.
		grms.		grms.	grms.	grms.	
Red Burgundy. Average of "grand crus"	11·1°	20·58	—	2·59	4·53	1·83	1·31
Cortona	11·2	23·8	—	3·76	—	1·92	1·28
Ordinary red Burgundy [1]	9·14	18·9	6·0	3·00	5·24	1·93	1·32
White Burgundy (average)	9·02	17·2	—	—	7·18	—	—
Red Bordeaux (average of "grands crus")[2]	10·4	20·3	—	2·09	3·93	2·31	—
Ordinary red Bordeaux (average)	10·3	22·08	7·3	1·57	4·3	2·33	1·58
White Bordeaux (Sauterne)	10·4	16·0	—	—	—	—	3·6
Medoc (Graves) . . .	11·6	23·0	—	3·66	4·45	2·47	1·60
Red wines of Narbonne .	11·0	18·8	—	1·80	4·2	3·20	0·95
Wine of Aramon of Herault	7·8	17·0	—	2·63	5·10	2·02	—
Red wines of Gers . . .	10·0	21·4	—	1·08	3·99	1·19	—
Red wines of Algeria . .	11·3	21·5	—	1·10	4·51	2·66	0·70
Red Italian wines (Marengo)[3]	11·25	16·05	7·94	—	9·0	1·20	1·79
Red wine of Tuscany (average)	14·2	13·9	8·78	—	6·56	1·82	9·25
Lacryma Christi (old red wine)	14·95	108·9	12·1	—	6·71	4·95	116·13
Muscat of Asti (white, two years)	13·73	16·05	7·94	—	9·0	1·20	1·79
Ordinary red Spanish wines	14·20	23·1	—	1·08	—	2·60	2·10
Average red Rhenish wines	11·50	27·0	—	—	7·0	—	4·09
Average red wines of Alsace	11·14	21·33	—	—	3·30	2·95	0·49
Average white wines of Alsace	10·22	19·54	—	—	3·30	2·21	0·87
Hungarian white wines (Feheztimpkon)	10·25	26·30	8·80	—	2·02	1·80	0·20
Hungarian wine (Tokay) .	12·00	72·00	9·0 [4]	—	7·02	3·00	—
Red wine of Corinth (Greece)	14·84	41·70	8·86	—	4·57	2·32	3·84

Wines, white or red, are slowly modified. The effect of their ageing consists : 1st, in the disappearance of a part of the fixed or volatile acids which, uniting with the alcohol, produce some fresh ethers accentuating and at the same time improving the bouquet and taste of these liquids ; 2nd, in the precipitation, by

[1] Analyses of twelve authentic Burgundy wines from two to four years old, by Ch. Girard.

[2] Average of twenty-one "grand crus" red Bordeaux. Analyses by the same.

[3] Analysis of Fausto Sestini.

[4] This wine contained 51 grms. of sugar per litre, in addition.

oxidation or other successive modifications, of colouring matters and tannins which leave a sediment in the form of lees. Old wine is more perfumed, lighter, less alcoholic, less charged with extract, and less intoxicating than new wine.

Dry wines are those in which the sugar has almost entirely disappeared. They give in the mouth a warm and alcoholic impression.

In *sweet wines*, on the contrary, the sugar remains and its sweetness blends with the vinous and perfumed flavour of the drink. These wines, coming usually from very ripe and sweet grapes, may reach, either naturally or by the addition of alcohol at the moment of fermentation, the standard of 17 to 18 degrees per cent. Several of these are also obtained by adding to some fermented and alcoholized wines a certain quantity of must of grape, fresh or cooked. Malaga, Muscat, Port, Madeira, Sherry, are sweet wines.

Sparkling wines are those which, such as the blanquette of Limouse, the wines of Asti, Champagne and Saumur, contain at the same time a certain quantity of sugar and a quantity of carbonic gas sufficiently abundant to produce, when the bottle is opened, a sparkling froth which gives to these wines the piquant taste of carbonic gas due, generally, to the fermentation which has continued after the liquid has been bottled.

We call some vinous liquids "piquettes," those which are derived from methodical mixing with a quantity of water, the fresh skins of grapes from which the forerunnings have already been extracted. These inferior wines are made on a vast scale, either for the current domestic needs, or with the object of adulterating genuine wines. The bouquet of bad wines is acidulous and rather agreeable when they are well made. Here are two analyses of them :—

	Inferior Wines made of the residuum of average Wine of Narbonne.	Inferior Wines made of the residuum of Wine of Roussillon (Grenach and Carignan).
Alcohol (in centesimal degrees)	5·9°	6·1°
Extract at 100	17·9 grms.	19·0 grms.
Reducing sugar	Traces	Traces
Tartar	3·59 grms.	3·30 grms.
Free tartaric acid	0·75	1·05
Ash	4·68[1]	4·94[2]
Total acidity in SO^4H^2	4·07	4·26

The liquids which are obtained by adding to the residuum separated from the wine by means of a first pressing, a certain

[1] This inferior wine corresponded to 2·75 of SO^4H^2 per litre.
[2] This inferior wine corresponded to 1·70 of SO^4H^2 per litre.

quantity of tepid sugared water, then submitting the whole afresh to fermentation, *we name sugared wines, grape-skin wines, wines of the second or third ferment, process wines, petiotisés wines*. The beverages thus obtained are agreeable and alcoholic and contain tartar in sufficient quantity; but they have neither the perfume, colour nor body of the wines of the first pressing. Their extract, vinous quality, their acidity and tannin are less than in wines properly so called. Here is a table of the composition of three of these wines made from the skins of grapes compared with the corresponding wines :—

		Alcohol.	Extract in vacuo.	Tannin.	Tartar.	Comparative Coloration.
Haut-Médoc	Wine of vintage	12·4	29·80	3·62	2·40	100·0
	Wine of corresponding residuum	11·0	18·13	1·48	1·98	23·6
Burgundy	Wine of vintage	10·6	24·10	2·73	2·68	100·0
	Wine of corresponding residuum	10·4	17·40	0·41	1·77	17·5
Isère	Wine of vintage	9·5	25·20	2·66	2·41	100·0
	Wine of corresponding residuum	9·1	15·70	1·20	1·89	51·5

Some inferior wines or small wines called *dry grape wines* which are to-day rather generally consumed, are made from *dry grapes*, especially those which come to us from Greece, Spain, Turkey and Asia Minor. The dry fruit is partially pounded and digested for several days with warm water, and then submitted to fermentation. 100 kgs. of dry grape of good quality can be made to give by this means about 3 hectolitres of a liquid showing 7 per cent. alcohol. These pseudo-wines are, as a rule, distinguished from ordinary wines by their richness in sugar and gums, and by their feeble proportion of tartar and extract. They are lacking in body and perfume.

A propos of red wines it is again necessary to point out the rather general practice, immemorial in the South of France, which consists of plastering the vintage in order to give the wine more colour, vivacity and body. In rainy and hot years, the principal object of plastering is to purify, to precipitate the albuminoid and microbes—in brief to preserve them. But this addition of plaster to the vintage has the effect of introducing into the wine a corresponding quantity, not of sulphate of lime, but of acid sulphate of potassium and free tartaric acid. It is certain that the sulphate of potassium which forms in these wines, is unpleasant to many stomachs, and the Academy of Medicine in Paris, as well

as the State, for the benefit of all interests, especially those of public hygiene, have a fixed maximum of plastering not exceeding 2 grms. at the most of potassium sulphate per litre of wine. In this dose, this salt is most often inoffensive. As a proof of this we may note the state of the southern populations, French, Spanish or Italian who have used these wines, spoken of as plastered, constantly for centuries. But in exaggerated doses, from 4 to 7 grms. per litre, as was formerly employed in plastering, this practice has a dangerous influence on the health and comunicates besides a bitter and hard taste to the wine which lowers its quality. The plastered wines lose about half of their natural phosphates. The non-plastered, on the contrary, gain in quality and fineness, if not in colour. It is necessary to be able to recognize that the antiseptic precautions applied to the grape, to the cellar and the casks, allow us to-day to do almost without plastering, even in the South of Europe and also in Africa.

Bibasic phosphate of lime added to the vintage, exercises on the wine the effects of clarification and preservation which are obtained with plaster without its inconveniences (Hugounenq). Phosphating is then preferable to plastering, at least from the hygienic point of view.

XXVI

CIDER—PERRY—BEER

NEXT to wine the most general alcoholic beverages are cider, perry, and above all, beer.

CIDER—PERRY.

Cider.—Cider is the fermented juice of the apple ; perry, that of the pear. These two liquids appear to have been known from time immemorial in Europe, where apple and pear trees are aboriginal. As early as Charlemagne we find, that in his Capitularies, that prince charges the administrators of his domains to engage men able to make cider or pommé (*pomarium*), men whom he calls *siceratores*.[1] Cider, which used to be made in most of the provinces of France, gradually disappeared wherever they succeeded in cultivating the vine. It was only towards the thirteenth century that it became the habitual drink of the Normans and then of the Bretons. However, it was made, and is still made, in small quantities in Maine, Gascony, Navarre, as well as in England and in the North of Italy.

In France the annual production of cider, which before 1880 did not exceed 10,000,000 hectolitres, reached an average of 14,000,000 hectolitres during the twenty years 1879 to 1899. Normandy and Brittany consume on an average, 212 litres of cider per man per year. The consumption of perry does not reach a tenth of this figure.

The *cider apples* are not generally edible. They are divided into three categories :—

Sour apples which give an acid juice, clear, light and liable to turn black.

[1] Frenchmen in old days wrote *sidre* and not *cidre*. This word comes from the Greek σίχερα which is itself derived from a Hebrew term which signifies an *intoxicating drink.*

Sweet apples, less rich in juice, which yield a luscious extract, and a cider which is very agreeable but which tends to become sour.

Bitter or rough apples which give a generous cider, coloured, having body and suitable for keeping.

The best ciders are made by mixing the two last varieties. Sometimes pears are added to the extent of one-fifth to give the cider more bouquet.

The cider apple when quite ripe is pounded mechanically, and 20 per cent. of water are added to it. After some hours it is submitted to pressure. 1,000 kgs. of apples thus yield 500 kgs. of juice. This residuum is afterwards mixed with 150 to 200 litres of water and gives another 250 litres which brings the quantity of must corresponding to 1,000 kgs. of apples up to 750 litres.[1] This juice is left to ferment either in casks or tubs, and after four or five days (the cellar being at a temperature which should not be less than 12° and not exceed 28°), it is decanted into small sulphured casks, the bung of which is only closed when the liquid has a density of not more than 1022, or 3° Beaumé. The cider is drunk after it has passed through the winter and has been clarified, when the slow fermentation is ended, and when its flavour is developed.

If we wish to obtain sweet and sparkling ciders, the fermentation is stopped when the liquid has only the degree of sweetness that is desired (or even a little more) ; from 8 to 10 grms. of bisulphate of potassium per hectolitre are added to the liquid and it is decanted into a small sulphured cask. After the winter, this clarified cider is bottled ; it remains sweet and in time becomes sparkling.

Cider is, as we see, a more or less artificial drink. Looking to the fruit which has furnished it and the subsequent preparations which it has undergone, it presents a very different composition. Here is the composition per litre of some good ciders according to the *Laboratoire municipal* and M. X. Roques :—

[1] In bad years the water added to cider ought to be diminished by half. If we wish the cider to have a richness of alcohol and to keep, we must add to the must a certain proportion of sugar. We reckon, that to raise the alcoholic standard 1 per cent. after fermentation, we ought to add 1,800 grms. of sugar per hectolitre of must, and in addition 100 to 150 grms. of tartaric acid per 100 litres of water.

Composition of some Ciders (per litre).

	Still Cider.						Sparkling Cider.		
	Sweet Cider. Average of 4 samples.	Coarse Cider (about Bayeux).	Pure Cider of the Plain (Yvetot).	Old Normandy Cider.	Still German Cider (Speierling).	Still German Cider (Borsdorfer).	Sparkling Cider of Redon (Brittany).	Sparkling Cider of Villaviciosa (Spain).	Sparkling Cider of Gournay.
Alcohol (in degrees)	1·7°	3·0°	4·4°	4·8°	5·5°	5·45°	5·25°	5·1°	5·25°
	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.
Dry extract at 100°	66·98	53·20	61·30	20·90	15·68	15·8	62·96	68·20	62·96
Reducing sugar	—	16·50	3·70	4·40	1·74	1·34	43·62	53·79	43·61
Tartaric acid	—	—	—	—	0·40	0·42	0·70	0·32	0·70
Tannin	—	—	—	—	0·19	0·19	0·54	0·06	0·54
Pectin		from 6 to	10 grms.	per litre					
Acidity in H_2SO_4									
,, total	2·67	3·23	4·54	5·36	3·14	2·79	2·89	3·92	2·89
,, fixed	1·76	2·68	2·31	2·59	2·15	2·35	2·06	2·86	2·06
,, volatile	0·91	0·55	2·23	2·77	0·64	0·79	0·83	1·06	0·83
Soluble ash	2·56	2·15	2·70	2·25	1·90	2·00	2·51	2·07	2·51
Insoluble ash		0·45	0·30	0·25	0·22	0·23	0·66	0·41	0·66

English ciders reach a standard of about 4·8° in the alcoholmeter, those of Jersey 4°, those of Normandy 4·6° to 3·5°. The standards of 5° to 6° are suitable for keeping ciders.

The amount of sugar in the juice of the apple being, on an average, 120 grms. per litre, the cider which comes from it should show 6·8 in the alcoholmeter ; this result is very rarely attained.

The tannin of cider is, like alcohol, a preserving principle, but if it is too abundant, the cider is rough and bitter.

The acidity of cider is due especially to malic acid with which are associated traces of tartaric acid. The pear being in general more acid and more astringent than the apple, we understand the utility of the pear in making good cider, but only a small proportion of it should be added.

The pectin or mucilaginous principle, forms a rather notable part of the extract. It gives body to the cider, which contains from 5 to 10 grms. per litre of it.

The colouring matter of cider is not well understood. Its perfume belongs to an essential oil partly formed of volatile ethers.

If badly cared for, cider acidifies or turns thick and ropy. This last fault can be remedied by adding at the same time tartaric acid, tannin and alcohol (500 cc. per hectolitre). In France they say that cider is " killed " when its light colour turns green or blackish. This is sometimes remedied by adding to the liquid 40 grms. of tartaric acid per hectolitre and a little tannin.

Cider is an excellent drink in which alcohol exists in an agreeable and diluted form. Nevertheless, for the worker who is greatly fatigued, it is not as good as wine, but it is as good and better than the latter as a refreshing liquid when it is mixed with water and used moderately. Cider, however, is a *cold* drink ; therefore like the beer-drinker, the cider-drinker accompanies his meal, if he can, with a small glass of brandy. It is there that the danger lies, the abuse of alcohol under the form of strong liquor very often growing little by little.

Cider agrees with plethoric, arthritic and gouty people, according to the evidence of Garrod, provided that these invalids are not at the same time lymphatic or suffering from cardiac affection. It owes these anti-gouty properties to its acid malates which excite renal activity and alkalize the blood.

Badly fermented cider, thick, acid, viscous and ropy, as it is often drawn from casks into which air and fungi penetrate, is a bad drink, sometimes harmful by reason of the free acids and microbes which it contains.

Perry.—Nearly all that we have just said of cider applies to perry. It should be made with special pears, quite ripe (mixtures of sweet and sour varieties), brewed at the moment when their pulp yields to the pressure of the finger. Pears being a little less rich in sugar than apples, their must is obtained by

adding to the pressed residuum only one-sixth of water. The fermentation ended, the liquid is clarified and can be put into casks or bottles. The taste of perry is excellent. When well made, it very much resembles light champagne. But, the inferiority of perry to cider is due less to its greater acidity, than to a special exciting action which it exercises on the nerves and brain, an action which appears to be due to the exaggerated quantity of amylic ethers which it contains.

Here is an average analysis after Behrend :—

Per litre.			
Alcohol (in degrees)	6·9°		
Extract dry at 100°	51·6	grms.	
Sugar	28	,,	
Malic acid	5·64	,,	Total 6·35
Acetic acid	0·71	,,	
Ash	4·3	,,	
Density	1·011	,,	

Beer

Beer is the result of the fermentation of the grains of cereals, saccharified by malt with the addition of hops, and submitted to the action of yeast which changes the sugar into alcohol.

It is the beverage of the countries in which the vine or apple does not grow well. It was known to the Egyptians, the Aryan people, Greeks, Gauls and Germans. To-day, in Europe alone, more than 128,000,000 hectolitres are consumed per annum, of which 36,000,000 are consumed in England, 24,000,000 in Germany and 9,000,000 in France.

Generally the first material of beer is barley grain ; but all grains rich in starch are susceptible of saccharification and can produce beer ; barley is preferable for reasons of economy and ease of manufacture. Rice and maize have also been much used for some years. Oats and rye yield a beer which clarifies badly and turns acid.

The manufacture of beer involves four successive operations : malting, brewing, hopping and fermentation.

Malting consists of transforming the grain into malt, that is to say into a product in which the starch is to a large degree changed into dextrin and sugar of malt or *maltose*. To effect this, the barley is moderately wetted and then spread in granaries warmed first to 18° and then to 30° and 34°. There it slowly germinates and at the end of seven or eight days the gemmule having reached the length of two-thirds of the grain, the germination is stopped by aeration and cooling, then by drying the whole in malt-kilns, rooms with perforated floors, when the grain is grad-

ually raised to an increasing temperature of 30° to 35°, then to 60°, 80° and beyond.

During its germination, a *diastase* is developed in the grain which, acting on the starch, transforms it almost entirely into dextrin and maltose, both soluble in water. Dessication has the effect of completing this action and afterwards of allowing the germ, which would give a bad taste to the beer, to be separated by means of special mills. A malt easy to keep and ready for the brewhouse is then obtained.

When it is desired to transform it into beer, it is ground and submitted to brewing. In this second operation the malt is macerated with water at 60°. The water dissolves the ferments of the malt, diastases and invertines, bringing them into close contact with the starch, dextrin and maltose. The ferments change these almost wholly into glucose directly fermentable and which dissolves in the liquid.

At last, the latter contains nothing more than some glucose, a little dextrin and some nitrogenous soluble substances originating from the grain, the albuminoid matters of which have been peptonized in a small proportion and transformed into different amides. This must is then raised to boiling point and from 600 grms. to 1 kg. of hops per hectolitre are added. The object of this is to aromatize the liquid and to make it keep better. The hops act chiefly by means of their bitter principle, *lupulin*, a yellowish secretion accumulated at the base of its bracts. Their tannin, by precipitating a part of the albuminoids, makes the beer also clearer and less changeable.

After hopping, the rapidly cooled must is submitted to fermentation. The latter can be carried out either at a temperature of 15° to 30° (*high fermentation*), or at about 4° to 5° (*low fermentation*). Very different beers are obtained by these two methods.

In *high fermentation* the must is put to ferment at about 10°, with the fresh yeast resulting from a previous high fermentation.[1] The splitting up of the sugars begins rapidly : they are transformed into alcohol and carbonic acid. This gas is dissolved in the liquid and is partly set free, at the same time that the yeast feeds and reproduces itself. At the end of some hours for small beers, and after two or three days for keeping beers, the fermentation is stopped.

In *low fermentation* the must is leavened at a temperature of 5° to 6° only, with some *low yeast*, a variety of yeast with ellipsoidal grains, and the liquid is kept in cooled cellars. The yeast falls to the bottom of the vats and the fermentation goes on slowly. After eight to ten days the beer is made. If we wish to obtain beers which are to be kept, a very slow fermentation

[1] Arborescent yeast with round cells.

is allowed to continue in the liquid kept in the cellar for seven or eight months at temperatures of 2° or 3°.

In Belgium and Holland some special acid beers called *Faro* and *Lambick*, are made with wheat malt. The must which comes from it, pretty generally hopped,[1] is, after cooling, put into fresh vats *without the addition of yeast*; a slow and special fermentation is developed in them whence result at once alcohol, acetic acid, lactic acid, etc. Finally, a clear, acidulous, slightly alcoholic liquid is obtained, one fairly easy to preserve.

Beer before being delivered for consumption should be generally clarified by settlement or by fining.

Good beer makes an agreeable, healthy and perfumed drink, with an alcoholic standard varying from 3° to 7° per cent. It is always charged with carbonic acid which makes it sparkling. It holds in solution some nitrogenous matters, glycerin, dextrins and sugars which communicate to it their nutritive properties; some bitter and resinous tonic products; acetic, succinic, lactic, malic and tannic acids; some salts, particularly alkaline and earthy phosphates.

Unfortunately beer is modified or adulterated, either by an excess of alcohol in order to give it more body and resistance to spontaneous alterations, or by replacing hops by the leaves of the pine, fir, box, willow; sometimes by quassia or gentian; more rarely by adding injurious bitter substances (picric acid, colocynth, coculus Indicus, nux vomica, strychnine). Traces of these latter substances suffice to give to beer a very pronounced bitterness. Preservative agents are also very often added: salicyclic acid and salicylates, sulphurous acid and bisulphites, oxalic acid, etc. Or it may be coloured with caramel, fat and the carbonate of ammonia mixed and superheated, etc. These are some of the bad practices which can only be noted here, and which may make this drink a dangerous liquid.

I recollect also that for some time, especially in England, beers have been consumed containing a quantity of arsenic sufficiently marked to have caused numerous cases of poisoning. These beers had been manufactured not from barley-malt, as it is made in Germany and France, but with syrups of glucose, themselves obtained by saccharifying starch or fecula of the potato by commercial sulphuric acid, which often contains much arsenic.

Lead ought to be banished from all the vats or pipes connected with beer.

Here are the compositions of some true barley and hop beers. I borrow them from *Les Documents du laboratoire municipal* of

[1] Each brewer adds a special infusion of plants which aromatize his beer according to the taste of his customers.

Paris (1885 ; p. 196 seq.) and from the important work, so often quoted, of J. Koenig :—

PERCENTAGE COMPOSITION OF SOME WELL KNOWN BEERS (FOR 100 CC.).

	Alcohol in vol. p. 100 or degree.	Dry Extract.	Ash.	Sugar.	Acidity in Lactic Acid.	Observations.
Tourtel beer (Nancy)	5·8°	7·6 g	0·35	—	—	—
Strasburg beer . .	4·8	5·62	0·30	0·85	0·41	d = 1·015
,, ,, . .	4·2	4·6	0·30	—	0·58	—[1]
Fanta beer (Paris) .	4·7	6·53	0·20	1·15	—	—
Munich (Salvator) .	4·35	9·78	0·7	—	0·18	—
Nuremberg . . .	4·5	7·05	0·23	—	0·17	—
Lowenbrau beer . .	3·0	6·0	0·25	—	—	—[2]
Bohemian beer . .	3·46	4·91	0·19	—	0·16	—
Dresden ,, . .	2·36	3·03	0·12	—	0·13	—
Hamburg ,, . .	3·98	6·76	0·25	—	0·16	—
Pilsen ,, . .	3·47	4·97	0·17	—	0·16	—
Dreher ,, . .	3·60	5·54	0·24	—	0·17	—
Porter (London) . .	5·2	6·4	0·32	—	—	—
Ale (Scotch) . . .	5·8	10·5	—	—	—	—
Faro	4·32	5·15	0·29	—	0·89	—
Lambick	5·94	3·30	0·31	0·48	0·99	—[3]

Beer is then less alcoholic than wine ; it is also less stimulating, less fitted to give resistance to fatigue. It introduces in the system for the average quantity of 32 grms. of alcohol per litre and 30 to 105 grms. of extract, a very great quantity of water. It only appeases thirst momentarily to excite it afterwards by the feeling of dryness and stickiness which it leaves in the mouth. It makes the drinker heavy, particularly by the specific action of the hop, an action which has been compared, although with great exaggeration, to that of Indian hemp. Its consumption, if often excessive, may lead to an atheromatous state of the heart and of the arteries, to the weakening of the power of resistance in illness, to the production of intestinal and vesical catarrh, especially if the beer is too new.

These are its defects ; but its qualities are also quite as remarkable : a good beer constitutes a refreshing drink, very agreeable, nutritive by its extract, by its nitrogenous principles as much as by its alcohol, its phosphates, its dextrins ; tonic by its bitter substances ; diuretic ; stimulating by its carbonic acid, light to the stomach.

[1] The ash of this sample had the following percentage composition : $SiO^2 = 16{\cdot}6$; $K^2O = 4{\cdot}8$; $Na^2O = 0{\cdot}5$; $P^2O^5 = 20{\cdot}0$; $PO^4MgH = 20{\cdot}0$; $PO^4CaH = 2{\cdot}6$.

[2] Ash containing per cent. : $SiO^2 = 14{\cdot}0$; $K^2O = 29{\cdot}0$; $Na^2O = 0{\cdot}1$; $CaO = 6{\cdot}0$; $MgO = 7{\cdot}7$; $Fe^2O^3 = 0{\cdot}8$; $NaCl = 6{\cdot}0$; $P^2O^5 = 29{\cdot}3$; $SO^3 = 5{\cdot}0$.

[3] With dextrin for $100 = 1{\cdot}84$.

The abuse of beer is conducive to obesity, to distension of the stomach ; it may become one of the predisposing causes of glycosuria, of gout, of atheroma of the arteries and hence, of diseases of the heart.

Germans are almost unanimous in declaring that beer taken while eating is unfavourable to digestion.[1] They drink it between their meals. Unless beer is taken in great quantities or is too new, it does not appear to me to possess any inconvenience when taken at meals.

From the hygienic point of view, replacing hops by other aromatic or bitter ingredients may be useful or dangerous : the shoots of the fir, birch and willow have been tried and may replace them without inconvenience. Gentian communicates to this drink a bitterness to which the stomach easily accommodates itself. But it is not the same with box and still less so with colculus Indicus, nux vomica, aloes and colocynth.

[1] Buchner, *Deuts. Arch. f. klin. Med.*, t. XIV, p. 3 ; Ogata, *Arch. f. Hyg.* t. III, p. 204.

XXVII

BRANDIES AND STRONG ALCOHOLIC LIQUORS—ALCOHOLISM

THE distillation of fermented liquors produces alcohol accompanied by the secondary products which form its bouquet and communicate to it the characteristics that show its source. The addition to these alcohols and *brandies* of extracts of fruits, perfumes and sugar provides the different alcoholic liquors (cassis, chartreuse, menthe, anisette, absinthe, etc.) which we sometimes take between or after meals.

Of all these strong liquors, *brandies* made by distilling wines are most esteemed. They show from 30 to 80 per cent. in the alcoholmeter.

The best known is *cognac*, produced by the distillation of the wines of Charente and more particularly of those produced by the vines called *folle blanche*. After making it by distilling the wines in little metal stills and before sending out cognac for consumption, it is kept for years in small oak casks in which it is slowly oxidized, its ethers are left to develop and it loses a part of its alcohol, becomes charged with colouring matters, borrowed from the wood of the cask. Good cognac shows then from 50° to 56° per cent.

The perfume of this exquisite drink is due chiefly to the ethers which are produced in it, to the essences pre-existing in the grape and to a feeble trace of hydropyridic alkaloids, sweet, but poisonous in a little larger dose, and which are formed during fermentation. Here, according to M. Ordonneau, is the composition determined with great care of one of these authentic cognac brandies, twenty-five years old and showing 50 per cent. In this analysis the numbers all relate to 1 hectolitre which was used for experiment. It weighed 91,000 grms. (see *Bull. Soc. Chim.*, Paris, 1886, p. 334). There were found in it :—

Ethylic alcohol	40,000 grms.
Other alcohols and different essences .	408 ,,
Water	59,592 ,,
	91,000 grms. = 100 litres

The 408 grms. of alcohol other than ethylic alcohol, and the different essences indicated in this analysis, were in their turn composed as follows :—

Acetic aldehyde	9 grms.
Acetic ether	35 „
Acetal	Traces
Normal propylic alcohol	40 „
Normal butylic alcohol	218·6 „
Amylic alcohol	83·80 „
Hexylic „	0·60 „
Heptylic „ / Superior „	1·50 „
Propionic and butylic ethers	3 „
Caproic ethers / Oenanthylic „ / Oenanthic „	12·40 „
Oenanthic acid	4 „
Different bases	Traces
Total	407·90 grms.

Isobutylic alcohol has not been found in this product. The quantity of amylic alcohol (the most dangerous of these alcohols) is, we see, only 0·83 grms. per litre of cognac, or 13 milligrammes per small glass of 16 cc.

Associated with the oenanthic ether, which contributes much to the flavour of cognac, we find some decigrammes in this liquor of a special terpene very oxidizable and boiling at 173°. This gives in part to wines and brandies their vinous character, so peculiar to them, and their perfume. Some open-chain amines and pyridic and hydropyric alkaloids (which I have since found in a very small proportion together with M. G. Halphen in musts and wines), also contribute to the bouquet of the brandies from Cognac, Armagnac, etc. According to M. Lindet, brandies made from wine residue and cider would contain from 5 to 6 milligrammes of these bases per litre.

The residue of fermented grapes distilled with water gives a brandy called an *eau de vie de marc.* It contains furfurol and some butylic and amylic alcohols in rather large quantities.

The juice of cane sugar, fermented and distilled, produces *rum.* The fermentation of molasses gives *tafia.* Rum contains in volume from 50 to 65 per cent of alcohol.

Under this name is also sold a product manufactured with the parts of brandies made from grains or potato most charged with amylic alcohol. These very noxious liquors may contain as much as 100 milligrammes of pyridic bases per litre. The taste and odour is disguised by adding an essence of artificial rum, a mixture of formate of ethyl and methyl.

Kirschwasser is obtained by distilling the fermented juice of wild or black cherries. It contains from 45 to 50 per cent.

of alcohol by volume. We find in it 30 to 100 milligrammes of hydrocyanic acid per litre.

Plum brandy, or *slibowitz*, is obtained by the distillation of the pulp of this fruit after fermentation.

Arack is the product of the distillation of fermented rice or of palm tree wine. It contains a somewhat large proportion of amylic alcohol.

Scotch whiskey is the result of the distillation of germinated and fermented barley.

Anisette is an alcoholic infusion of anise or of the aniseed tree. It is a sweetened liqueur containing a feeble quantity of these essences.

Absinthe.—This dangerous and strange beverage is obtained by distilling with alcohol the tops of large wormwood, hyssop, angelica, seeds of the aniseed tree, anise, fennel, etc. The liqueur absinthe contains, per litre, from 1 to 3 grms. of these essences. Its alcoholic standard varies from 40° to 70°. Absinthe is sometimes coloured with the juice of the nettle or hyssop, turmeric and sometimes even with aniline colours.

The effects of this beverage are much more formidable than those of the alcohol which it contains.[1] We shall return to this point later.

Chartreuse, which slightly reminds one of absinthe, offers several varieties; the *green* is the richest in alcohol. It is an alcoholate properly sweetened with juniper with tips of fir and odoriferous alpine plants.

Bitter is obtained by steeping in alcohol at 50 to 60 per cent. some peel of bitter oranges and also different essences or aromatics varying according to the brand.

Cassis is an infusion made, when cold, of the well ripened fruit of the black currant bush in brandy of 50 or 60 per cent. At the end of some months the liquid is filtered and saturated with sugar. Taken in small quantities, as one often drinks it at the end of a meal, cassis is an inoffensive tonic and digestive liqueur.

Vermont[2] is obtained by the infusion in white alcoholized wines (18 to 20 per cent.), dry or sweet, of a certain number of roots or bitter species (small centaury, gentian, peel of bitter

[1] An average dose of 30 grms. of absinthe liqueur contains:—

	Alcohol.	Essence of Absinthe.	Other Essences.
Half-refined absinthe	15 grms.	0·010 grms.	0·046 grms.
Refined absinthe . .	20·4 ,,	0·010 ,,	0·084 ,,
Swiss absinthe . .	24·2 ,,	0·010 ,,	0·085 ,,

[2] From the German *Wermuth*, absinthe.

oranges), then adding a flavour or extract of odoriferous plants (absinthe, cinnamon, nutmeg, meadowsweet, etc.), the flavour differing according to the brand. To sum up, it is a white wine strongly aromatized and alcoholized, the bitterness of which slightly stimulates the stomach, *if it is used in moderation.* It is drunk pure but more often mixed with water.

We cannot here enlarge further on the other liqueurs or artificial alcoholic drinks, such as gin, curaçao, kummel, maraschino, noyeau and many others.

Here is the summary composition per litre of the best known liqueurs :—

ANALYSIS OF SOME LIQUEURS.

	Specific Weight.	Alcoholic Degree.	Sugar.	Other Extract.	Ash.	Authors.
Absinthe . . .	0·9116	58·9°	0·00	4·99	—	Adrian ; Deschamps.
Bitters	1·071	52	325·7	34·3	0·43	Krauch and Aldendorff
Kummel . . .	1·083	34	311·8	8·4	0·58	—
Curaçao . . .	1·030	55	285	1·0	0·4	—
Yellow Chartreuse	1·080	43·2	343·5	17·8	—	O. Reinke.
Bordeaux Anisette	1·085	42	344·4	3·8	0·4	Krauch and Aldendorff

ALCOHOLISM.

The abuse of spirituous liquors or alcohol in its natural state has become, like opium, one of the scourges of humanity. In Africa, in America, in Australia, it is in a fair way to destroy entire populations. It threatens and strikes everywhere the strongest races. From year to year the danger continues to increase.

In France the consumption of alcohol in its natural state has increased from 1·46 litres per head per annum in 1850 to 3·8 litres in 1888. In Paris to-day it exceeds 7 litres. The consumption is more than 8 litres per head in Germany and Belgium, 5·5 litres in Hungary, 9 litres in Holland. About 1884, before the repressive licensing laws for alcoholic drinks in Russia, it had risen to 9 litres in the province of Moscow and to 16·58 litres in the town of St. Petersburg !

Thus it is that nearly everywhere the consumption of alcohol is increasing, and everywhere are increasing with it, crime and insanity. The fact that the abuse of alcohol arises in short from misery and ignorance and engenders them in its turn, bringing with it a train of pathological and moral consequences which we will run over here very rapidly.

In the case of the man who has just taken too much alcoholic liquor, the momentary sensation of well-being and apparent vigour which follows the introduction of the first quantities of

fermented liquid or alcohol in its natural state, is quickly succeeded by a general excitation, and exaltation of sensibility, of thought and of the physical forces, a very slight giddiness and a little genetic ardour ; it is the beginning of intoxication.

If the dose has been sufficient, to these phenomena are soon added more or less delirious conceptions, disorder of speech, incoordination of ideas and movements, a tendency to congestion, to insensibility, to muscular relaxation and to collapse if moderation has been too far exceeded. A deep sleep of some hours' duration, followed by perspiration and an abundant flow of urine, mark in general this state of acute poisoning by alcohol.

If this is often renewed, and even without this daily excitation needing ever to reach drunkenness properly so called, the individual becomes by degrees alcoholic.

Dyspepsia and gastritis are the rule in the case of these latter invalids. After rising from bed, they at once feel sensations of nausea. The liver congested, then fatty, becomes enlarged in volume, and later on it may become cirrhotic. The face gradually assumes a special pallor. The mucous membrane of the larynx and bronchi is purple and thick, the voice becomes hoarse ; there is respiratory oppression and a passive and continuous congestion of the lungs with a manifest disposition to tuberculosis. The heart tends to become hypertrophied.

In a more advanced stage one perceives troubles of the sensibility and memory, insomnia, depression, anxiety, anguish, dyspnœa and hot or cold sensations, hyperaesthesia of certain parts, especially of the soles of the feet ; then a more or less intermittent anaesthesia which may spread from the extremities to the trunk. The alcoholic sees scintillations and *muscae volitantes* before his eyes, and has buzzings in the ears.

The intelligence is slowly obscured, the brain and the nervous matter, incessantly congested and impregnated with alcohol, as Maurice Perrin and M. Nicloux have proved, are not long in degenerating, *delirium tremens* and insanity show themselves.

These then are the troubles of the chronic poisoning, a state which henceforth the smallest quantity of alcohol, a glass of wine, some cubic centimetres of brandy are sufficient to keep up. Sometimes these unfortunate creatures appear calm and preoccupied as it were with a dream or fixed idea ; sometimes they are restless, victims of delirious ideas which haunt them especially during the night ; very often they injure and strike those who approach them ; they are pursued by the idea of suicide or murder, or they are seized with foolish gaiety. Their muscles are twitched by uneven movements, they have convulsive uncoordinated tremblings, followed sometimes by genuine epileptic fits. The attack of alcoholic delirium is terminated by a deep sleep which only leaves the invalid a vague

remembrance of what has happened, with a general extreme lassitude and a slight muscular trembling.

A graver matter is that the alcoholic transmits his defects by heredity. A great number of children of these unhappy people are victims of convulsions, subject to epilepsy, tuberculous meningitis, hysteria and scrofula. At a certain age, the desire for strong liquids develops in them too ; they become susceptible, nervous, violent and vicious and produce a fresh generation of degenerates or madmen.[1]

Unfortunately in France alcoholism, favoured by wrong ideas about the Budget and politics, has for some years been making formidable and rapid progress. The defective will and perhaps the ignorance of public bodies and forgetfulness of moral laws, thus little by little lead to this decadence all those whose ignorance and whose passions are not considered.

All alcohols are not equally toxic[2] : vinous alcohol is less dangerous than the superior alcohols, but as it is much more abundant, it is to this that the phenomena of alcoholic intoxication are more particularly attributable (Joffroy). Here are, according to Dujardin-Beaumetz and Audigé, the relations of

[1] Out of a litter of twelve pups given birth to by a normal bitch mated with a vigorous dog, but who for eight months had been receiving 11 grms. of absinthe per day, there were two stillborn ; seven others succumbed shortly after birth to tuberculosis, enteritis and epileptiform attacks. An unintelligent and lazy bitch given birth to by a mother who had been subjected to chronic alcoholism mated with a normal vigorous dog bore three pups ; one died a few hours after birth ; at the autopsy—an atrophy of the big toes, a club foot and a cleft palate were found. (Mairet and Combemale, *Acad. Sciences*, t. CVI, p. 667.)

Gilbert, Ballet and Faure observed during four years five pairs of alcoholized dogs. None of the pups born during alcoholization lived more than a month, they were all attacked by convulsions and showed arrests of development, etc. Livanoff has shown that rabbits chronically alcoholized, present a general atrophy of all the viscera (except the spleen which is increased 30 per cent.). M. Nicloux, as has already been stated, has shown that alcohol passes from the mother to the foetus, and invades the organs while being formed. It also passes into the spermatic matter (P. Renault).

In the case of animals which, subjected to chronic alcoholism, do not succumb during the course of the experiment, it has been observed that they become either thinner or fatter. Many become snappy, vicious and unintelligent. Others are seized with muscular tremblings, convulsions, epileptiform attacks, gastric and intestinal intolerance. The stomach becomes congested, the glandular epithelium degenerates and becomes sclerosed. Cirrhosis of the liver has not been proved to be a result of alcoholism. The lungs, heart and meninges are normal.

On the subject of *alcoholism* and its effects see the article by R. Romme, *Revue générale des Sciences*, July 30, 1902, from which we have partly borrowed these facts.

[2] See on this subject *Recherches sur la puissance toxique des alcools*, by Dujardin-Beaumetz and Audigé. Doin, publisher, Paris 1879, 1 vol. in -8 ; and Joffroy, Paris 1890.

toxicity between the different products extracted from fermented liquids :—

Toxic Doses per kilogramme of Animal (Dog).[1]

Ethylic or vinous alcohol	7·75 grms.	Oenanthylic alcohol	8 grms.
Pure methylic „	7·0 „	Glycerine	8·75 „
Propylic „	3·8 „	Acetic aldehyde . .	1·1 „
Isopropylic „	3·7 „	Acetic ether . . .	4·0 „
Butylic „	2·0 „	Acetone	5 „
Amylic „	1·6 „		

1·50 grms. to 3 grms. of ethylic alcohol per kg. weight of the body cause transitory drunkenness ; at 6 grms. the results are very severe and death comes in two or three days.

From the point of view of their increasing harmfulness, the industrial alcohols should be classified as follows :—

1. Alcohol and brandy.
2. Cider brandy.
3. Brandy made from residue of grapes and perry.
4. Alcohols and brandies from grains.
5. Alcohols from beetroot.
6. „ „ potatoes.

According to M. Antheaume,[2] a litre of the following alcoholic drinks kills the weight of living subjects which we here indicate :—

Pure ethylic alcohol . .	64 kilos	Kirschwasser at 50° .	64·5 kilos
Martinique rum . . .	65 „	Brandy from cider at 50°.	65 „
Cognac at 50°. . . .	65 „	Brandy from plums at 50°.	63·2 „
Brandy from the residue of Burgundy . . .	68 „		

We see that if the impurities of alcohols are much more dangerous than ordinary alcohol, the preponderance of the weight of this latter in the different liqueurs determines the greater part of the toxicity of these products which appear to vary only slightly.

But if vinous or industrial alcohol has essences of anise, badiane, origan, mint, balm-mint, absinthe, etc., added to it, the harmful effects are very sensibly increased. The most dangerous of these liqueurs are the two last, but more particularly absinthe. It can produce in time in the drinker, alcoholic delirium, violent and criminal madness and epileptiform convulsive attacks. Absinthism is even more dangerous than chronic alcoholism.

A healthy and sufficient diet, facility for obtaining *a light wine* and *beer* cheaply, and the use of tea and coffee, are the best dietetic means with which to combat these grievous habits.

But it is above all necessary that the workman should know that in being driven to drink, he becomes debased and degraded, that an iniquitous toll and tax are thus levied upon his salary, and that the only result for him and his, can be physical and moral misery.

[1] By subcutaneous injections.

[2] See the thesis of Antheaume, Paris 1897.

XXVIII

CONDIMENTS

TO the aromatic or alcoholic foods and beverages which we have just studied, should be added the *condiments* with which we supplement the different dishes in order to heighten their flavour, to perfume them and to excite the digestive organs. At most all are agents of high seasoning, serving to awaken the appetite, not to satisfy it.

Several, such as the aromatic spices, wine, coffee, tea, etc., correspond to a sort of universal instinct which tends to associate sensations of an almost artistic order with the coarse gratification of hunger.

We have already spoken of Pavlow's researches relative to the influence which gustatory and psychical impressions exercise upon the secretory nerves of the stomach and of the intestine the activity of which they provoke. It is not to be doubted that in virtue of this mechanism condiments do facilitate the digestion and assimilation of foods. It is in this sense that they may be agents of economy. It is certain that the people who use them to the greatest extent are also the most sober. Speaking of the arrival of the Chinese in the Moluccas, Raynal (*Hist. Philos.* I, p. 17) writes : "A sober, independent people, opposed to work, had lived for centuries on flour of sago and cocoanut milk when the Chinese, having landed by chance in the Moluccas, in the middle ages, discovered there cloves and nutmeg, two precious spices that were unknown to the ancients."

Of these condiments those to which every rational and well regulated kitchen has recourse, from the clove and nutmeg to sugar and salt, are valuable agents, which accelerate the circulation, the intestinal secretions and digestion ; but one must not use them to excess. After any excitement of the nervous system, one is conscious of relaxation of the mind, fatigue, debility and insensibility. Every one knows how much the exaggerated use of spiced condiments, for example, quickly fatigues the stomach which they excite and cloy very rapidly, causing the appetite to disappear. Like coffee, alcohol, wines, perfumes, it is necessary to know how to use condiments in moderation if one does not wish to lose, and more than lose, all the benefit which they may procure for us.

In modifying almost indefinitely the savour and the odours of the same foods, such as meat and vegetables, condiments enable us to endure and digest them more easily. They also allow us to moderate the use of alcoholic drinks.

Several of these ingredients play yet another part. They behave like antiseptics, keeping in check microbic fermentation, either directly or by favouring the action of the soluble digestive ferments and the hydrochloric acid which the intestine secretes more abundantly under their influence. The aromatic spices, salt, garlic, horseradish, mustard, etc., are antiseptics. They improve the taste of foods, often coarse, sometimes even indigestible or damaged, which they render acceptable or inoffensive. Hence their widespread usage from time immemorial among the working classes.

We shall divide condiments into aromatic, acrid or peppered, alliaceous, acid, salted, sugared and condiments of animal origin.

(*a*) *Aromatic Condiments.*—The principal are: Vanilla, cinnamon, clove, nutmeg, aniseed, cumin, fennel, chervil, parsley, saffron, laurel, sage, savory, pimpernel, etc.

All these ingredients contain essential oils, aromatic, excitant and antiseptic. We shall say of each of them only what is indispensable.

Vanilla is the siliquous fruit of the *Epidendron vanilla*, an orchid of Mexico, Columbia and Guiana. The most esteemed is in pods 16 to 18 centimetres long, deep brown, with a soft surface, often covered with a crystalline *rime*. They exhale a sweet odour which they owe principally to the *vanillin* or *vanillic* aldehyde $C^6H^3(COH)^1(OH)^4(OCH^3)^3$. Good vanillas contain from 1·5 to 2·5 per cent. of it. This essence is accompanied by vanillic acid, fatty matters, a slightly odorous resin, and sometimes by another aldehyde which gives to the fruit a slight perfume of heliotrope.

Vanilla in powder or in pods serves to aromatize sugared dishes, chocolate, etc.

Vanillin, or rather a glucoside capable of producing it by hydrolysis, exists also in oats. It is one of the agents of the stimulation which this food effects in the animal which feeds on it.[1]

Nutmeg is the kernel of the fruit of the nutmeg tree (*Myristica moschata; Myristiceæ*). Its powder exhales a strong aromatic odour; its taste is both pungent and hot. A fragrant butter is obtained from the nutmeg, formed of myristin $(C^3H^5)'''(C^{14}H^{27}O^2)^3$ mixed with other oily glycerides, and with an essence $C^{10}H^{16}$ which boils at 165°, and has a strong flavour and a very well developed odour of nutmeg (*Cloëz*).

[1] Vanillin appears sometimes to exist in the blood of the horse fed on oats; it has been found in some indigenous plants, among others in the *Epipactis atrorubens* (L. Maillard).

The *clove* is the unopened flower of the clove tree (*Caryophillus aromaticus* of the myrtaceæ family). The cloves of the Moluccas and of Bourbon are the most esteemed. This spice, which serves to perfume our dishes, contains, according to Trommsdorff, 18 per cent. of a volatile essence, pungent and aromatic, formed, out of 100 parts, of 92 parts of eugenol and 8 parts of a hydrocarbon in the $C^{10}H^{16}$ group. The eugenol $C^{10}H^{12}O^2$ is the monomethylic ether of an allylpyrocatechine or allylgaïcol $C^6H^3(CH—CH^2{=}CH^2)^1(OH)^3(OCH^3)^4$. It is also met with in the essence of cinnamon bark.

In connexion with this oil, there is found in the clove a bitter and astringent matter (17 per cent.); water (15 per cent.); a resin (6 per cent.); cellulose (28 per cent.).

Cinnamon is formed of the rolled bark of the *Laurus cassia* and *cinnamomum* (*Lauraceæ*) trees of Ceylon and China. Its colour is fawn, its taste hot, sweet and aromatic. It contains an essence formed of cinnamic aldehyde C^6H^8O or $C^9H^5—CH{=}CH—COH$, cinnamene C^8H^8, cinnamic acid, a resin and a little eugenol.

Aniseed is the fruit of the *Pimpinella anisum* (*Umbelliferæ*). It has been from time immemorial mixed with certain kinds of cakes. It is used to perfume liqueurs and sweets. Its taste is piquant, agreeable, sweet and aromatic. Anise contains, like *fennel*, another umbelliferæ also employed to aromatize some dishes, a hydrocarbon of the $C^{10}H^{16}$ system and a crystallizable ether, *anethol* $C^{10}H^{12}O$ or $C^6H^4(OCH^3)(CH{=}CH—CH^3)$ which is again allied with the preceding essences.

The concrete part of the essences of star aniseed (badiance) and of tarragon has a similar composition and constitution.

Cumin, the seeds of which are also employed as if they were aniseed, contains an analogous essence from which cuminic aldehyde $C^{10}H^{12}O$, and even anethol are extracted.

Chervil, which enters into our seasonings because of its agreeable aromatic flavour, is also furnished by an umbelliferæ (*Chœrophyllum sativum*). It is the same with parsley (*Apium petroselinum*) the leaves of which are used to perfume the most various salted dishes. There is found in it an essential oil with a piquant odour and an oleaginous principle, apiol $C^{12}H^{14}O^4$ or $C^6H(CH^2—CH{=}CH^2)^1(OCH^3)^2(O^2CH^2)''^4$ having a congestive action on the uterus and ovary.

Sage, Wild Thyme, Thyme, Savory,-etc., which are used to aromatize our foods are labiated plants with analogous essences. That of thyme is acrid, very aromatic and penetrating and contains principally thymol $C^{10}H^{14}O$ or para-isopropylmetacresol

$$C^6H^3(OH)^3(CH^3)^1\left(CH\begin{matrix}\diagup CH^3\\ \diagdown CH^3\end{matrix}\right)^4.$$

This body is accompanied by a little thymene $C^{10}H^{15}$ and cymene $C^{10}H^{14}$.

The *laurel*, another ingredient used in our kitchens, i he aromatic and stimulating leaf of the *Laurus nobilis* (*Lauraceæ*).

The leaves of the cherry-laurel serve to perfume milk foods, syrups, etc. They owe their perfume to the essence of bitter almond C^7H^6O and to hydrocyanic acid feebly combined together.

Saffron is obtained from the stigmas, dried on screens, of the flower of the saffron or *Crocus sativus* (*Irideæ*). It is cultivated and employed as seasoning, especially in Spain, in the South of France and Italy. It communicates a yellow colour to the dishes and an indefinable flavour, very peculiar, slightly sweet, bitter, aromatic and exciting. It contains 7·5 per cent. of a volatile essence, a fatty body fusible about 48°, an abundant colouring matter (68 per cent.) and *crocin* $C^{16}H^{18}O^8$ or *polychroïte* soluble in water and diluted alcohol. This latter is capable, by hydrolysis, of being divided into sugar and an essential oil $C^{10}H^{14}O$ of a strong saffron odour.

Curcuma is used in India under the form of seasoning and often also in France, in the *cary* or curry mixed with capsicum and other aromatic spices. It is the root of an amomaceæ *Amomum curcuma*) of Central Asia. It owes its flavour in a large measure to an acrid and odoriferous oil. It contains in abundance a yellow resinous matter, fecula, etc. Curcuma is an exciting and diuretic tonic.

(*b*) *Acrid or Peppered Condiments.*—Amongst these we will mention ordinary pepper, ginger, capsicum, kava.

These are excitants of the stomach and of the digestive tracts which they irritate and congest. Their antiseptic action is very restricted.

Pepper is perhaps the most used of all spices. It comes to us from Malabar, Java, Borneo, Sumatra, Guiana. It is the fruit of the pepper-plant, a shrub of the family of the Piperaceæ. It is picked as soon as it is ripe and dried on canvas. It is the size of a very small pea covered with a very wrinkled rind, containing a greyish white seed, rather hard, of an acrid and aromatic flavour. This is the ordinary grey pepper. This same peeled seed, after steeping in salt or lime water, becomes white pepper, which is whitish grey and smooth on the surface.

Pepper contains with a little ligneous matter, starch and some mineral salts, an essential volatile oil of the $C^{10}H^{16}$ system with the odour of pepper; a very acrid concrete oil; about 1 per cent. of a toxic alkaloid, piperidin, $C^5H^{11}N$, and especially a crystallizable nitrogenous matter feebly alkaloid, the piperin $C^{17}H^{19}NO^3$ which pepper yields to alcohol. Potash transforms it into piperidin $C^5H^{11}N$ and piperic acid $C^{12}H^{10}O^4$ which seems to have itself the constitution $C^6H^3(C^4H^4\text{—}COH)(O^2CH^2)''$.

The average composition of pepper is according to Ch. Girard:

Water	12 per cent.	Albuminoid matters	2 per cent.
Volatile oil	1–2 „	Starch	18 „
Piperine	16 „		

White pepper leaves about 1 per cent. of ash; the grey from 4·1 to 5·6. The alcoholic extract may vary from 6·5 to 13·3 per cent.

Pepper irritates the digestive and urinary tracts. It is aphrodisiac.

Kava is another pepper not used in Europe. Its leaves serve as a masticatory in Eastern Asia. They are acrid, astringent, aromatic and sialagogue.

Ginger is the tuberculous root of an Amomaceæ of the Indies of Mexico, of the Antilles and of Cayenne, the *Zinziber officinale*. Its brownish powder possesses an acrid and sweet flavour, a strong odour, aromatic, slightly peppered. It is often added to pastry and to other foods.

As regards vegetables we have already spoken of capsicum (see p. 254). It is slightly perfumed and more or less charged with a very acrid substance, capsicine, volatile at 100°, with an extremely stinging and caustic odour and flavour. The most dangerous of all is Cayenne pepper, *capsicum baccatum* or *fastigiatum*. It comes from India and Java.

(*c*) *Alliaceous or Allylic Condiments.*—Garlic, eschalot, scallion, onion, leek, rocambole, all furnished by the Liliaceæ family; horseradish, and especially mustard, of the family of Cruciferæ form this class of condiments.

Except mustard, they have been already sufficiently described under ordinary vegetables (p. 241).

The flour of mustard is prepared by pounding the seeds of *Sinapis nigra* (Cruciferæ). It contains sweet oily glycerides (26 to 28 per cent.), glucose, gums, different colouring matters, chlorophyll, salts; but its chief characteristic is the myronate of potash from which the essence is derived. This salt represents 1 to 2 per cent. of the weight of the seed. The essence of mustard, indeed, does not exist at first in the fruit; it is developed in the flour only by the addition of cold or tepid water (not boiling), which, dissolving a diastase, myrosin, allows this ferment to act on the myronate of potash (*Bussy*). Under this influence this salt decomposes into glucose, sulphocyanide of allyl and bi-sulphate of potash according to the equation:

$$\underset{\text{Myronate of potash.}}{C^{10}H^{18}NKS^2O^{10}} = \underset{\text{Sugar.}}{C^6H^{12}O^6} + \underset{\text{Sulpho-cyanide of allyl.}}{C^3H^5N{=}C{=}S} + \underset{\text{Bisulphate of K.}}{SO^4KH}$$

The essence of mustard is constituted by the sulphocyanide of allyl thus formed.

Horseradish, cress, radishes, contain the same principle and the same essence.

Its action, irritant to the tongue and the olfactory nerves, is borne well by the stomach, the secretions and vigour of which it increases. But it possesses another valuable property besides, that of being one of the most powerful antiseptics known. The sulphide of allyl $(C^3H^5)^2S$ of garlic and of other alliacea possesses the same characteristic. Mustard, garlic and onion allow then of the digestion of foods, sometimes doubtful, by exciting the stomach and rendering the digestive tracts aseptic.

(*d*) *Acid Condiments.*—Vinegar, lemon, capers, gherkins and other preparations of this nature compose this fourth class.

These condiments excite the taste and the appetite by their organic acids, free or in the form of acid salts : acetic, citric, malic, tartaric, oxalic acids. . . . . They put the salivary glands and the stomach into a good digestive state if they are used in moderation. Mixed with water and sugar they provide excellent beverages to quench thirst.

Vinegar made from wine, and especially that of wine from esteemed vintages such as Burgundy, Bordelais, South of France, Spain and Italy is a condiment of an agreeable and perfumed taste which has nothing but the acetic acid in common with the vinegars from beer, wood-alcohol or pyroligneous acid, etc. The colour of wine vinegar is yellow or red, its acid flavour is pure, its odour ethereal and delicate. It is often perfumed too with tarragon. Good vinegar may contain per litre from 40 to 60 grms. of crystallizable acetic acid with which are joined the salts of the wine, and particularly cream of tartar.

The vinegars of cider and perry somewhat suggest these liquors by their taste. They are yellowish and do not contain any cream of tartar.

The vinegar of beer is yellow and suggests sour beer.

Vinegar from wood always keeps a slight pyrogenous taste.

That which is obtained by acidifying commercial alcohol by *mycoderma aceti* is not sensibly superior to it. These are liquors of which the dull acid flavour does not well satisfy the sense of taste.

Capers, gherkins, pickles, etc., owe their acidity to the vinegar which is perfumed, as the case may be, with pepper, spices, tarragon, laurel, etc.

(*e*) *Salt Condiments.*—Various salts of potassium, soda, lime, magnesia and iron are suitable for purposes of alimentation and play there an important part, as we shall see later (p. 321).

But of all these salts chloride of sodium, or kitchen salt, is the salt which we introduce in its natural condition into our food. Salt exists in our extra-cellular plasmas, and we shall return again later to the importance of the part it plays in connexion

with saline foods. We daily add directly from 6 to 8 grms. of it to our food. This addition is the more necessary the more alimentation is impoverished in chlorides. We have already said that salt protects the albuminoid substances against dissimilation. Salt is then pre-eminently an economical food. It enables the herbivora to take and digest fodder which they would refuse if it had not been previously salted. It excites the production of milk. It provokes in the omnivora the secretion of a more acid gastric juice.

(*f*) *Sugared Condiments.*—We shall place among these condiments cane sugar, milk sugar and honey, although these ingredients are also genuine foods.

Cane sugar or *saccharose* is extracted from the sugar cane, in the colonies, and from sugar beetroot in Europe. It is this which is principally found in sugared fruits slightly or not at all acid. Whatever be its origin, saccharose has always the same composition and corresponds, when it is pure and crystallized, to the formula $C^{12}H^{22}O^{11}$. We will not describe this product here. It will suffice to say that this sugar, which is the commonest sugar, is white, crystalline, inodorous, very sweet, soluble in the third of its weight of water at 15° and in the fourth at 100°. Simple syrup of chemists is made with *white sugar* 1,000 and water 525. This syrup boils at 105° and keeps without fermenting or turning brown.

When saccharose is melted at 160° it gives a thick liquid which in cooling turns into a vitreous mass. It is this product which is wrongly called *barley sugar*.

Saccharose is not only a condiment, it is also a food. Formerly a luxury, and even a medicine, it was replaced for the sake of economy by honey and the concentrated juices of sweet fruits. In France to-day 160,000,000 kgs. of sugar are consumed and, it seems, more than three times as much in England.

In passing through the alimentary canal, cane sugar is inverted or changed into equal parts of glucose and levulose ; saccharose could not be directly assimilated if it were injected in the veins, as has been shown, since 1848, by Bouchardat and Sandras.

Sugar is pleasant to the taste and nourishes after the manner of starch and fats. It is partly stored up in the liver under the form of glycogen.

Lactine or milk sugar $C^{12}H^{22}O^{11},H^2O$ exists in the milk of mammals and also in some vegetables. Cow's milk contains 40 to 50 grms., human milk 70 grms. of it per litre. It is a white substance, rather hard, which crackles between the teeth, not very sweet and soluble in six parts of cold water. Its specific rotatory power is $[\alpha]d = +52°5$. It may ferment directly under certain conditions. It is to this fermentation that koumiss and kephir owe their alcohol. Milk sugar is transformed in the intestine into galactose and

glucose which are afterwards reabsorbed. These sugars act like heat-producing foods. But M. Mosso has proved that, injected into the veins or given directly to animals, they possess also an evident exciting action on muscular contraction.

We find in acid fruits such as cherries, grapes, gooseberries, etc., some inverted sugar formed by almost equal parts of glucose and levulose. This mixture is especially met with in honey. It is known that this product is disgorged by the bee after it has fed on the nectar of flowers. Separated from the cake of wax where it has been deposited, honey constitutes a semifluid substance which becomes concentrated and hardens. It is formed of a mixture of glucose, levulose and a little saccharose with small quantities of aromatic and colouring principles.

The most esteemed are those which come from Greece, Narbonne and Gâtinais. Honey may be preserved indefinitely.

It is slightly laxative, especially the highly coloured kinds.

Mead was the liqueur, more or less alcoholic, which was obtained by dissolving honey in ten to twelve times its weight of water and keeping this solution for some time ; it then underwent a spontaneous alcoholic fermentation.

(*g*) *Condiments of Animal Origin.*—The preparations of half fermented fish, anchovies, caviare, botargo, made cheeses and extract of meat itself, should be cited in this place.

The preparations of fermented fish which appear to be highly prized by the Chinese, and formerly by the Ancients, are not so esteemed by us.

Anchovies preserved in pickle, in pepper and other spices, smoked herrings, etc., are at the same time foods and stimulants of the appetite and digestive functions. *Botargo*, highly appreciated as a condiment on the French Mediterranean shores, is made of mullets' roes or of umbrina dried in the sun in the envelope of their gland. One should compare with this caviare, the eggs pressed and salted, sometimes slightly smoked, of the great sturgeon, the sangle, the ablet and bream. Like botargo, caviare, concerning which we have already said a few words (p. 204), forms a dish very rich in nucleoproteids and other nitrogenous and phosphorated principles giving by decomposition some hexone bases (Kossel). Here is the composition, rather variable however, of the caviare of the sturgeon, as being the best known :—

	Caviare of Sturgeon.	
Water	37·5	56·97
Nitrogenous matters	29·2	27·87
Fatty matters	6·3	12·85
Other non-nitrogenous organic matters	7·8	—
Mineral salts	9·3	2·31

A part of the salts mentioned in these analyses (4·8 out of 9·3 in the first case) is chloride of sodium added to this preparation.

The caviare of Astrakan is more esteemed than that of the Elbe. Certain caviares (the *Iastychnaïa* for example) are prepared with very ripe eggs fermented and salted.

All these preparations appear to be very easily digested.

Anchovies preserved in brine, aromatized with pepper, laurel, etc., form a delicate dish and a stimulant to the appetite. They contain in 100 parts : Water, 58 ; albuminoids, 23 ; fats, 2·3 ; and salts, 24, of which 19 to 20 are ordinary salt.

XXIX

INORGANIC FOODS

THE system not only needs organic alimentary matters; water and the fixed mineral substances are absolutely indispensable to it. We shall first consider the latter.

We have already seen (p. 29) that mineral salts enter into the composition of all the organs and plasmas of animals. In the bones, muscles, nerve-tissues, skin, different glands, blood, lymph, etc., these substances exist in relative quantities almost invariable, and for each organ they vary little according to the state of health. Normally, mineral matters only change in absolute quantity and proportions from one tissue to another: fresh muscles contain 1·1 to 1·3 per cent. of them, the blood 0·9 to 1·15, fresh bones 34 to 37 per cent. These statements will suffice by themselves alone to show that these salts play an important part in the organs since they are localized in them by selection.

On the other hand, saline matters are constantly eliminated by the urine, fæces, sweat, epithelial desquamation, etc. The adult thus loses every day 26 to 27 grms. of these substances, about half of which is made up of sea-salt. The growth of young animals further increases the need of fixed salts: 3 to 3·8 grms. of phosphate of lime are necessary per week to form the body of the young child; he must then find about 0·27 grms. of lime and nearly 0·10 grms. of phosphorus every day in the milk and other substances on which he is fed. The foods ought to repair these losses incessantly and to supply these mineral needs.

The salts of the organism play besides an important part in the nutritive exchanges. Between two different contiguous cells, or between each of these cells and the plasma which bathes them, it is necessary, in order that the nutritive exchanges may be accomplished, that there should be a cause producing the circulation of the products. Salts, in becoming diluted in the humours of the organism, introduce their osmotic tensions that are best compared to a tension of vapour which presses on the cell walls and tends to traverse them in such a manner as to establish isotony, that is to say, equality of pressure on the two sides. Hence, this circulation from outside to inside and from inside to outside which, according to the nature of the

dissolved salts, carries away, chemically or physically, the substances which are either combined with these salts or dissolved, the products of secretion and the matters for assimilation.

Thus, as soon as one attempts to deprive the organism of its mineral matters, the discomfort daily becomes greater. However sufficient the alimentation may be in other respects, cachexia and death are the consequences of this privation.

Chossat, Boussingault, then Forster and many others, studied the effects on the organism of this privation of salts. Forster[1] fed some dogs with the powder of boiled meat drained of water (it only left 0·8 grms. of ash per cent.) ; to this aliment he added starchy substances and fats in the quantities and proportions of normal alimentation. He noticed that as the organism grew poorer in salts, the subjects under experiment grew weaker : stupidity, trembling, muscular weakness, sluggishness of the lower parts and convulsions appeared. Finally digestive troubles and vomitings took place. The animals died at the end of twenty-six to thirty-six days, whereas some other dogs subjected to complete alimentary inanition lived from forty to sixty days.

Kemmerich also tried to feed two dogs with meat exhausted of salts by boiling water. To this imperfect nutriment he added, in the case of one of the two animals, a little of the residue obtained from the incineration of meat broth, in the case of the other, sea-salt only. The first dog prospered, the second no longer increased in weight. This observation at once shows the preponderating influence of certain mineral salts which are met with in the tissues and plasmas, in particular of the alkaline and earthy phosphates of extract of meat.

The fact is that all the proteid matters of our cells and humours are united to these phosphates, without which they would not be able to perform their functions.

The indispensable mineral matters are brought to us by the usual foods in very different forms. Substances of animal origin contain, united with their albuminoid substances, organic phosphorus and sulphur which, by their decomposition and oxidation in the economy, are changed into phosphoric and sulphuric acids, thus furnishing an excess of these acids which tends to acidify the blood. The vegetable foods, on the contrary (except bread and cereals), always bring us an excess of bases. Thus they alkalize the humours.

The following table gives, for 1,000 parts of fresh foods, the quantity in grammes of the alkaline and acid principles which they contain. We shall notice the relative poorness of animal foods in basic contributions and, on the contrary, the richness

[1] *Zeitsch. für Biolog.* t. IX, p. 297 (1873). See also R. Tigerstedt, *Lehrbuch der physiolog.* 1897.

of the vegetable foods in alkalies and even in phosphoric acid, but always with an excess of alkaline bases.

CONTRIBUTIONS IN BASES AND ACIDS OF SOME FOODS OF ANIMAL OR VEGETABLE ORIGIN.

For 1,000 fresh parts.	K^2O	Na^2O	CaO	MgO.	Fe^2O^3.	P^2O^5.	SO^3.	Cl.
	grms.	grms.	grms.	grms.	grms.	grms.	grms.	grms.
Meat of mammals	3·5	0·55	0·51	0·4	0·03	4·2	2·2	0·6
Liver . . .	3·0	1·2	0·15	0·01	0·20	4·6	0·09	0·3
Brain . . .	1·15	1·0	0·03	0·41	0·08	1·13	0·14	0·4
Flesh of pike .	1·46	1·24	0·45	0·23	—	2·32	0·15	0·3
Human milk .	2·03	0·59	0·85	0·17	0·01	1·22	—	1·12
Cow's milk .	2·39	1·50	2·16	0·28	0·004	2·65	—	2·28
Wheat bread .	1·69		0·89	—	—	3·35	0·119[1]	—
Haricots . .	13·2	2·80	1·97	2·11	0·35	11·5	1·60[2]	0·8
Peas . . .	9·58	3·75	0·68	2·41	0·27	9·67	0·99[3]	0·14
Beans . . .	6·24	5·71	2·17	2·66	0·30	11·38	0·40[4]	0·24
Cauliflowers .	0·26	0·11	0·17	0·02	0·004	0·13	0·11[5]	0·06
Apples . . .	1·30	0·95	0·15	0·32	0·05	0·50	0·22[6]	—

As the flesh of animals contains a quantity of pre-existing phosphoric and sulphuric acids, capable of saturating, and more than that, all the bases contained in this food, it follows that the carnivora which feed exclusively on it, could not find in it the materials suitable for alkalizing their blood. Moreover, as we have just said, the oxidation of the sulphurated and phosphorated organic products of this muscular flesh gives also a certain proportion of free sulphuric and phosphoric acids. Finally, the dissimilation of the nucleins of the meat produces a fixed acid, uric acid, which tends to acidify the blood and plasmas. Unable to find in their food the alkali to neutralize their humours, the carnivorous animals procure it by means of a mechanism on which we have been enlightened chiefly by Schmiedeberg and Walter and later by Hallevorden.[7] They perceived that, in the case of carnivorous animals and even in the case of omnivorous ones which do not get a sufficient quantity of vegetable alkalies, the organism by the destruction of its albuminoids makes alkaline bases, especially ammonia, and that in a greater proportion according to the greater abundance of the acids to be neutralized. But this mechanism, very powerful in the carnivora, has however a limit, the omnivorous animal cannot long do without alkaline foods, and particularly vegetables.

[1] This number 0·119 refers to the silica SiO^2, in this case, and not to SO^3.
[2] In addition $SiO^2 = 0·14$ grms. [3] In addition 0·06 grms. of SiO^2.
[4] In addition 0·73 grms. of SiO^2. [5] In addition 0·128 grms. of SiO^2.
[6] In addition 0·16 grms. of SiO^2.
[7] *Arch. f. exp. Path.* t. VII, p. 148, and t. X, p. 124.

The calculation of the table (p. 31) of mineral losses which the adult undergoes in twenty-four hours by the urine, fæces and sweat, leads, in the case of acids and bases, to the following numbers corresponding to the daily needs of the organism in each of the mineral principles :—

MINERAL SUBSTANCES NECESSARY PER 24 HOURS.

Bases.		Acids.	
K^2O	3·22 grms.[2]	P^2O^5	3·9 grms.[1]
Na^2O	7·70 „	SO^3	2·03[1] „
CaO	1·47 „	SO^2	0·25 „
MgO	0·56 „	Cl	8·50[2] „
Fe^2O^3	0·04 „	CO^2	0·05 „

Let us see how we obtain these materials.

Alimentary Alkalies.—The allowance for twenty-four hours containing 107 grms. of albumin corresponds to about 1 grm. of sulphur which, oxidizing to the extent of four-fifths in the system, will give 2 grms. of sulphuric anhydride SO^3. The organic phosphorus is transformed, by the same mechanism, into about 0·3 grms. of phosphoric anhydride P^2O^5 per day. These acids would require altogether 2·3 grms. of potash, K^2O (or the corresponding quantity of Na^2O), in order to be neutralized as they are in the blood and humours. Such is the minimum quantity of these bases, that we ought to find each day in the vegetable foods alone capable of presenting them to us in the form of organic salts fit to be transformed into carbonates in the system.

The different foods are far from bringing us the two principal alkalies, potash and soda, in equal quantities. The following table, drawn up by Bunge, gives the absolute and relative richness in potash and soda of the different tissues, humours and alimentary substances. All the numbers are expressed in grammes and refer to 1,000 dry parts of each food :

	K^2O grms.	Na^2O grms.		K^2O grms.	Na^2O grms.
Rice	1	0·03	Herbs	6–18	0·3–1·5
Oats, Wheat, Rye, Barley	5–6	0·1–0·4	Beef	19	3
			Ox-blood	2	19
			Milk of a bitch	5–6	2–3
			Human milk	5–6	1–2
Apples	11	0·1	Haricots	21	0·1
Peas	12	0·2	Strawberries	22	0·2
Milk of herbivora	9–17	1–10	Potatoes	20–28	0·3–0·6

[1] In reality we do not receive from our daily foods the 3·9 grms. of P^2O^5 and 2·03 grms. of SO^3 here indicated; but the organic phosphorus and sulphur of these foods, passing into the system in this form, ought to be included here in the form of P^2O^5 and SO^3.

[2] Including the chlorine and sodium of the salt brought by alimentation for twenty-four hours.

Meat and milk bring us only very little of salts of soda : 0·07 per cent. of chloride of sodium in muscular tissue ; 0·1 in milk.

Except for the blood, we see the small part that soda plays in the living body in comparison with potash. It is in fact by the potash that the tissues are alkalized, and it is owing to this that the combustions are brought about which tend to provoke the oxidizing ferments. It is then potash (bicarbonate, tartrate, citrate, etc.) rather than soda or sodium carbonate which it is expedient to introduce into the system when one wishes to accelerate organic combustion. For that matter this is what plants achieve. They possess the singular faculty, even in the soils poorest in potash, even in those in which soda predominates, of choosing the salts of potassium necessary for their wants and of transforming them, by a mechanism which still escapes us, into organic acid salts.

Brought to our tissues by the foods, these salts are transformed into carbonates owing to the oxidation of their combustible part, either in the cells or in the blood of herbivorous and omnivorous an mals where they meet sodium chloride. They immediately undergo with it a double decomposition. This results in carbonate or bicarbonate of soda which alkalizes the plasma of the blood, and chloride of potassium which is partly eliminated by the kidneys. The carbonates of potash and soda, as well as the soda set free by the production of the gastric hydrochloric acid which the peptons neutralize, are afterwards united with the phosphoric and sulphuric acids coming from the oxidation of the phosphorus and sulphur of the albuminoids, as well as with the taurocholic and glycocholic acids incessantly poured into the intestine in the form of salts of soda ; these phosphates, sulphates and other sodium salts, which have become useless from that time, are thrown out with the urine and fæces. We lose each day from 9 to 14 grms. of sea-salt and from 2 to 4 grms. of potash K^2O by the urine. Hence the animal's constant need of alkaline salts : of those of potash, in the form of assimilable and combustible organic salts ; of those of soda in the form of chloride, of which the negative element passes into the gastric juice, which the basic element alkalizes the plasmas and forms the biliary salts. In the case of the omnivora, a small part of the acids originating from the organic combustions is also neutralized by a little ammonia formed in a small proportion at the expense of the albuminoids. These ammoniacal salts are partly thrown off with the urine.

The sea-salt and the salts of potassium having thus disappeared by double decomposition and afterwards renal elimination, the want of these alkalies makes itself felt afresh ; hence the continued necessity of alkaline bases.

On the other hand, in the case of the flesh-eater, the production of ammonia becoming preponderant, the need of salts of soda or of potash diminishes or disappears. Thus whilst frugivorous and omnivorous populations endeavour to obtain alkaline salts, carnivorous individuals and people (Ostiaks, Tongousses) do without these salts to a very great extent.

The more vegetable the diet, the greater is the amount of sea-salt which should be added to the food. Generally 8 to 9 grms. per day is sufficient.

Whatever be the method of alimentation, salt always remains in the blood a very nearly constant quantity except in complete and prolonged abstinence, when it may fall to a third of its usual amount.

C. Voit[1] Dehn,[2] Schaumann,[3] and A. Javal have observed that the addition of sea-salt or chloride of potassium to the food of animals produces polyuria and azoturia. Under its influence urea, *even if the water taken into the stomach is not increased*, is eliminated in greater abundance. C. Voit, in an experiment which lasted forty-nine days, found an increase of 106 grms. of urea in the total compared with the ordinary elimination.[4] The other alkali salts possess an analogous action, but much less pronounced.

It is owing to these salts, and particularly to the chloride of sodium, that the majority of the products of dissimilation are eliminated by the kidneys : urea, complex amides, leucomains, etc., and, in the case of diabetics, glucose, either because these bodies are united directly with these salts, or because the products of decomposition of the tissues are rendered soluble and are carried out by the soda, like the biliary acids, soda which, originating itself from salt, has undergone a double decomposition with the potassium salts of the tissues. It is known that chloruration of the organism increases hydrochloric stomachal secretion (Dastre, Linnossier).

Thus we understand the beneficial influence of ordinary salt on health, in particular that of stable animals, an influence to which is perhaps added that of small quantities of arsenic which I have always found in sea-salt, and which, in these feeble doses, stimulates very favourably the vital mechanism. Hence also the well known action of salt on the appetite and fecundity.

Complete privation of salt has the effect of considerably reducing that which we eliminate by the urine. From the third day onwards this quantity falls to 2 grms. then to 1 grm. or a

[1] *Untersuch u. d. Einfluss des Kochsalz*, 1860.

[2] *Pflüger's Arch.*, Bd. XIII, p. 367.

[3] *Dissertat.* Halle, 1893.

[4] It is to a certain extent by the same mechanism that the salting of meat partly eliminates the extractives in the form of brine.

little less and afterwards remains constant (Forster). If salt is then given to the creature, this salt accumulates in the blood until the normal amount is re-established. On the other hand, if deprived of salt, the creature tends to dehydrate itself ; whence has arisen the practical observation concerning the treatment of œdema, dropsies, ascites and Bright's disease by dechlorination. We shall return to this point à propos of methods of treatment.

Salts of the Earthy Alkalines.—The salts of lime and magnesia are not less indispensable to life than the alkaline salts. They are very unequally furnished to us by the articles of food. The following figures, which indicate their richness in these bases, are borrowed from Bunge :

For 100 parts of Dry Food.	CaO	MgO.
Cow's milk	1·51	0·20
Yolk of egg	0·38	0·06
White of egg	0·13	0·13
Human milk	0·243	0·05
Beef	0·029	0·15
Brain	0·080	0·24
Wheat	0·065	0·24
Potatoes	0·10	0·19
Peas	0·137	0·220

Lime, like magnesia, is found in the system : 1st. *Under the organic form* of lecithins, lecithalbumins, etc., or under still more complex forms of such a kind that these elements cannot be detected before the organic molecule which contains them has been destroyed. Magnesium is better fitted than calcium to furnish these complex combinations.

2nd. Under *a semi-organic form* united to the albumins and complex substances of the tissues, under the form of albuminates which can be broken up by means of the action of weak acids and dialysis.

3rd. *Finally under the form of* mineral or organic *salts* soluble or insoluble (sulphates, lactates, phosphates, etc.) which allow of the circulation and excretion of these combinations of metals.

It was interesting to see how these two bases vary *in the case of the same animal.* Here are the quantities of lime and magnesia found in the different organs of the same dog by Professor Aloy[1] of Toulouse. All these proportions are calculated in milligrammes and refer to 1,000 parts of fresh tissue :—

[1] *Le calcium et le magnésium chez les êtres vivants,* by Prof. F. Aloy. Toulouse, 1897.

	Dog weighing 10·5 kgs. (3 yrs. old).		Bitch weighing 13·2 kgs.		Ca/Mg		Average.
	Ca	Mg	Ca	Mg			
Brain	28	84	14	72	0·33	0·19	0·26
Muscle	147	270	196	332	0·54	0·60	0·57
Defibrinated Blood *globules*	very sm.	0·05	nil	0·02	very small		very small
Defibrinated Blood *serum*	80	24	50	12	3·3	2·7	3
Hair	185	19	280	22	8·2	12·7	10·4
Aponeuroses . . .	130	0	180	36	4·0	5	4·5
Bone (tibia) . . .	21000	450	18900	631	40·6	31·1	38·3
Heart	357	440	380	498	0·81	0·76	0·78
Liver	175	48	259	66	3·6	3·9	3·7
Kidney	238	126	350	192	1·8	1·8	1·8
Spleen	392	54	448	72	7·5	6·3	6·8

In the case of the horse, Prof. Aloy has found per kg. :—

	CaO	MgO
Brain	0·050	0·150
Muscle	0·310	0·740

We see that magnesia predominates in the brain, muscles, globules of the blood, thymus and suprarenal capsules. Eggs are also very rich in magnesium. Microbes themselves could not do without it. In no case can lime replace magnesia. For foods, magnesia accompanied by phosphates of potassium is met with, especially in the seeds. It is abundant in wheat bread, potatoes and the other tubercles, as well as in vegetables. It is always accompanied by phosphorus. Lime, rare in these different parts of animals and plants, exceeds magnesia in the other organs. It is the base which is most especially abundant in foliaceous parts. In the case of animals, it predominates in the supporting bony connective and cartilaginous tissues. Let us note that in the brain, magnesium is four times more abundant than lime ; probably it exists there (in part at least) in the organic state, as I have shown it happen in the case of chlorophyll.

Magnesium is then the specific metal of the most differentiated organs, and calcium that especially of the supporting tissues. We see this well in the case of vegetables ; 100 parts of ash contain, according to Boussingault :—

	K^2O.	CaO.	MgO.	P^2O^5.
Grain of wheat . .	30·12	3·0	16·26	48·30
Straw ,, . .	16·17	7·28	4·70	4·14

It is the same in the case of the animal, as the figures of the preceding table show.

The excretion of lime is irregular and varies with alimentation. Being a secondary chemical means of support, this base may undergo variations independent of those of the protoplasma.

It is not the same in the case of magnesia : belonging to the most differentiated parts of the cell, its excretion follows the variations of that of urea or nitrogen in the case of the animal. With regard to this, here are some figures due to Prof. Aloy :—

	Urine during 24 hours.	CaO.	MgO.	Urea.
Alimentation very much animalized	1·350 lit.	0·31	0·27	38 grms.
	1·400 „	0·30	0·28	42 „
Ordinary mixed diet	1·350 „	0·27	0·15	27 „

Bunge had already given the following figures :—

	Urine during 24 hours.	CaO.	MgO.
Meat alimentation	1·672 lit	0·328 grms.	0·294 grms.
Bread „	1·920 „	0·339 „	0·130 „

According to Mairet and Thorion, brain work greatly increases the excretion of these two bases.

The calcium salts are necessary to the constitution of the blood as antihaemorrhagics, and to the heart as stimulating its contractions. The serum of Locke (*Water*, 1000, $CaCl^2 = 0{\cdot}20$ grms. ; $KCl = 0{\cdot}20$ grms. ; $CO^3Na^2H = 0{\cdot}20$ grms. ; $NaCl = 9{\cdot}50$ grms. ; glucose = 1 grm.) injected tepid into the vessels, maintains the beats of the heart, even when extracted from the chests of animals, and causes these beats to return when they have stopped for some time. This same serum, when decalcified, no longer acts.

The experiments of Chossat on the alimentation of pigeons, of Boussingault on that of pigs, of Kemmerich on that of man and the dog, show that in the case of young animals or adults that have been deprived of lime, this base is assimilated even when it comes in the form of mineral salts, phosphates and carbonates, by foods and drinking water.[1]

Chossat had already demonstrated in 1842 that pigeons fed on grains of corn carefully chosen only form fragile bones. They only form a good skeleton when they receive lime. Seeds in fact furnish a great deal of magnesia but little lime. Fowls in granitic countries accustom themselves to the phosphate or even sulphate of lime, and this base is found again in their bones in the form of phosphate or in the shell in the form of *carbonate*. Partly deprived of lime, these animals become but slightly prolific.

The mineral salts of these bases can then be assimilated ; nevertheless the assimilation is infinitely better if the lime and magnesia are offered to the animal in an *organic* form, the metal

[1] A pig under experiment fixed in ninety-three days, according to J. Boussingault, 150 grms. of lime in its bones ; the analysis of its foods showed that they only contained a total of 98 grms. of lime. The difference of 52 grms. came from the water taken in.

remaining so to speak latent in these combinations, as in bread, milk, and dry vegetables, etc.[1]

Introduced into the system in the intermediary form of salts with organic acids, lactates, malates, glycero-phosphates of lime or magnesia, these bases are only assimilated with greater difficulty and incompleteness.

In an alimentation surcharged with calcium or magnesium, the excess of lime and magnesia is eliminated by the intestine, a small part passes by the kidney.

Iron, Manganese.—Even in a state of absolute inanition we eliminate every day some iron, especially by the fæces. It comes in a large degree from the dissimilation of the red corpuscles. This elimination increases in fever (Salkowski). Boussingault,[2] estimates the daily need in iron of the full grown man at 0·060 grms. or 0·080 grms.

This metal exists in an organic and latent state, or simply in the mineral state, in many foods. Here are some figures on this subject borrowed from Boussingault and Bunge :—

Iron (in Milligrammes) in 100 Fresh Parts (Boussingault).

Butcher's meat	37·5 mg.	White bread	4·8 mg.
Pig's blood	63·4 „	White haricots	7·4 „
Veal	2·7 „	Lentils	8·3 „
Flesh of fish	7·5 „	Potatoes	6·6 „
Hens' eggs	5·7 „		

Iron (in Milligrammes) in 100 Dry Parts.

Hæmoglobin	340 mg.	Peas	6·4 mg.
Hæmatogen	290 „	Potatoes	6·4 „
Pig's blood	622 „	Lentils	9·5 „
Yolk of egg	10–24 „	White haricots	8·3 „
Cow's milk	2·3 „	Carrots	8·6 „
Human milk	2·3–3·2 „	Rye	4·9 „
White of egg	traces	Wheat	5·5 „
Flour of wheat	1·6 mg.	Rice	1–2 „
Bran of Wheat	8·8 „	Apples	13 „
Bread	1·3 „	Cherries	10 „
Cabbages (inner yellow leaves)	4·5 „	Strawberries	9·0 „
		Hazel nuts (shelled)	4·3 „
Cabbages (outer green leaves)	17 „	Almonds (shelled)	4·9 „
		Figs	3·7 „

Iron certainly exists in the greater part of these foods under a metallic-organic form united with the protoplasms, and comparable with the hæmoglobin of the blood and with the hæmatogen (see below). It is only necessary to remark that this richness

[1] M. Vaudin has shown that in milk, the phosphates are dissolved by means of the milk-sugar, and that the products of saccharification of starch dissolve several insoluble earthy salts (*Bull. Soc. Chim.* t. XXVII, p. 416).

[2] *C. Rend.* t. LXIV, p. 1,353.

in iron, calculated here for foods in a dry state, is compensated by the large amount of water which constitutes them. Red wine is also very rich in iron, especially when it is new.

It is an interesting fact that milk is the poorest of all the foods in this metal. The explanation of this fact, apparently paradoxical, is due to Bunge : he establishes the fact that during the fœtal life, the embryo accumulates at the expense of the blood of the mother (and in the case of the bird borrowing from the yolk of the egg) an organic ferruginous substance, *hæmatogen*, a true nucleo-albumin, which the young animal, at its birth, possesses stored up in its organs and particularly in the liver. This matter, very rich in iron, is comparable to hæmaglobin. It is consumed little by little by the young being, in proportion as its blood is formed.[1] M. Lapicque, who has confirmed the observations of Bunge, has found in 1,000 grms. of liver, cleansed of blood, the following quantities of iron : at eleven days 0·20 grms. ; at twenty-one days 0·14 grms. ; at three months 0·043 grms. ; at six months 0·040 grms. Krüger has also shown that the fœtal liver in the case of a cow is ten times richer in iron than of the full-grown animal.

The hæmatogen of the yolk of egg contains, according to Bunge : C = 42·19 ; H = 6·08 ; N = 14·7 ; S = 0·55 ; P = 5·19 ; O = 31·0. Fe = 0·29.

A substance of the same nature has been detected also by Stoklasa in the nucleus of vegetable cells.[2] One kilogramme of dry peas has yielded 0·9 grms. of it. The *Boletus edulis*, a mushroom free from chlorophyll, contains 3·05 grms. of it per kilogramme. Stoklasa found 1·68 grms.of iron in 100 grms. of this substance.

It is scarcely doubtful that vegetables also contain an analogous nucleoproteid of manganese. Manganese has been detected in the ash of many comestible vegetables ; in that of the cauliflower, asparagus, salad, grape, wheat and maize, etc.[3]

The absorption of mineral iron by the alimentary canal (salts of iron with mineral or organic acids) is to-day positively assured. In these conditions this iron passes more abundantly by the urine and may accumulate in the liver. But the greater part of that which we assimilate by foods, is in the form of ferruginous nucleoproteids or hæmoglobins.

It is only eliminated in extremely small proportions by the urine and the bile.

Iron introduced by foods or medicaments, accelerates the intraorganic oxidations of carbohydrates just as much as of proteid bodies (Linnossier and Debierre ; Pokrowski). Boussin-

[1] M. Zalesky, *Zeitsch. physiolog. Chem.* t. X, p. 453.
[2] *Bull. Soc. Chim.* t. XVII, p. 523.
[3] *C. Rend.* t. LXXV, p. 1,213.

gault estimates a man's need of iron at 60 or 90 milligrammes per day.

Let us now pass to the mineral acid principles that foods bring us.

Chlorine, Fluorine, Bromine, Iodine.—These elements come to us partly (chlorine chiefly) from salt, the important part played by which we have previously shown. Fluorine comes to us especially from drinking waters, probably in the form of alkaline fluorides ; bromine and iodine appear to enter into the constitution of the bromic and iodic nucleoproteids, comparable to those that are met with in the thyroid gland or in the iodospongin. Iodine predominates especially in the thyroid gland (*Baumann*): it contains 0·075 to 0·130 grms. per cent. of it. There is a far smaller proportion of it in the other organs ; thus, in the rabbit Gallard has found (*C. Rend.*, t. CXXVIII, p. 1,120) :—

Blood	0·42 mg. per 100 grms.
Heart and lungs	0·50 ,,
Liver	0·13 ,,
Kidney and spleen	0·15 ,,
Brain and cerebellum . . .	1·10 ,,

Bromine and iodine are given us chiefly by certain plants. Amongst the iodized vegetable aliments we may cite particularly the following, according to Dr. Bourcet[1] :—

	Iodine per kg. of fresh material.		Iodine per kg. of fresh material.
Asparagus	0·24 mg.	Sorrel	0·12 mg.
Garlic	0·21 ,,	Household bread . .	0·000 ,,
Pine-apple	0·31 ,,	Green peas	0·080 ,,
Carrots	0·134 ,,	Potatoes	0·010 ,,
Mushrooms	0·172 ,,	Leeks	0·12 ,,
White-heart cabbage .	0·21 ,,	Pears	0·017 ,,
Strawberries . . .	0·17 ,,	Grapes	0·020–0·00 ,,
Flour of wheat . . .	0·007 ,,	Rice	0·17 ,,
Flour of oats . . .	0·009 ,,	Lettuce	0·012 ,,
Green haricots . . .	0·32 ,,	Tomatoes	0·023 ,,
Dry white haricots . .	0·014 ,,	Artichokes	0·017 ,,

Fruits and foods very rich in starch contain very little iodine. Grapes and wine are more or less iodized according to the nature of the soils.

According to the same author, amongst foods of animal origin, the most iodized are the following :—

	Iodine per kg. of fresh material.		Iodine per kg. of fresh material.
Eel	0·80 mg.	Oyster	1·37 mg.
Anchovy	0·95 ,,	Lobster	1·78 ,,
Bream	1·25 ,,	Whiting	0·31 ,,
Crab	1·82 ,,	Fresh cod	1·23 ,,
Grey shrimp	5·91 ,,	Fresh salmon	1·40 ,,
Roach	1·38 ,,	Fresh tunny	0·88 ,,
Smoked herring . . .	1·57 ,,	Trout	0·08 ,,

[1] See the fine treatise of P. Bourcet, Thèse de Paris, 1900, p. 65 (*Travaux de mon laboratoire*).

Bromine always accompanies iodine and often increases or diminishes like it, without, however, being proportional to it.

Sulphur, Phosphorus and Corresponding Acids.—Borrowed originally from the soil, especially in the form of sulphate, perhaps partly under the form of organic compounds (such as volcanic soils, produce), sulphur comes to us chiefly through the vegetable and animal albuminoids. Oxidized in the system, about four-fifths of this element reappear in the form of sulphates in the urine, a fifth remains in the form of cystin, taurin and other sulphuretted bodies of an unknown nature. A little sulphur is thus thrown out by the various excretions, and the epidermic products, such as the nails and hair. An adult man eliminates on the whole 1 grm. of sulphur per day.

It has not been shown that the mineral sulphur of our foods can co-operate in the formation of the specific albuminoids of the tissues.

Phosphorus and its compounds are indispensable to the fixing of albuminoid matter by animals and to their growth. It comes to us through foods under the two forms of phosphates and organic phosphorated compounds, lecithins, nucleins, nucleon or phosphocarnic acid, lecithalbumins, protagons, jecorins, inosic acid and other complex bodies in which it may sometimes be very abundant.

In the foods of animal origin, the following quantities of *organic phosphorus* directly assimilable are found [1] (expressed in P^2O^5):—

	Human Milk per litre.	Cow's Milk per litre.	Eggs (yolk only).	For 100 grms. of Fresh Meat.
Casein	0·132grms.	0·580 grms.	—	—
Vitellin	—	—	0·059 grms.	0·060 grms.
Lecithin	0·133 „	0·091 „	0·071 „	0·039 „
Nuclein	0·171 „	0·087 „	—	0·008 „
Other combinations insoluble in water	—	—	—	0·128 „
Combinations soluble in water, not precipitated by CaO	—	—	—	0·039 „
	0·456grms. (0·48 grms. of P^2O^5 total)	0·758 grms. (1·81 of P^2O^5 total per litre)	0·130 grms. (No mineral phosphorus)	0·274 grms. (0·450 grms. of P^2O^5 total)

Brain, liver, thymus, kidney, milt, contain almost the whole of their phosphorus in the organic state. The flesh of the lobster contains as much as 2·20 per cent. of it. The yolk of

[1] Gilbert and Posternack, *La médication phosphorée,* December 1903, p. 26.

egg, the milt of fish and the nervous tissue are rich in nucleins and consequently in phosphorus. Of all the foods of animal origin, the thymus (12 grms. per kg.) and then the cardiac muscle (10 grms.) are the richest in *total phosphorus*. The brain and the liver only contain respectively 8 grms. and 5 grms. per kg., the kidneys 4·5 grms. The foods richest in *organic phosphorus* are, in decreasing order, the thymus, brain, muscles, liver and kidneys (A. L. Percival, *C. Rend. Acad. Sciences*, Dec. 1, 1902. *Travaux de mon laboratoire*).

It is chiefly, but not solely, in an organic form that phosphorus is assimilated by the organism. It has been long known that the soluble phosphates, alkaline or earthy, are only assimilated with difficulty. Here are a few fresh experiments made on man in reference to this subject,[1] by MM. Gilbert and Posternack.

In a *preliminary period*, these scientific men submitted themselves to a slightly insufficient nitrogenous alimentation and drew up the complete schedule of the elimination of nitrogen and phosphorus. They found :—

	N.	P^2O^5.
Introduced by foods in 5 days	89·8 grms.	12·15 grms.
Found in the excretions :		
Urine	88·62 „	9·86 „
Fæces	12·25 „	3·75 „

Thus, in this period and with this alimentation, the organism insufficiently nourished lost in five days 11·07 grms. of nitrogen and 1·084 grms. of P^2O^5. During a second period and without changing anything in the alimentation of the subjects, an addition was made of 1·2 grms. of phosphoric acid in the form of bicalcic phosphate, and 2·6 grms. in that of monocalcic phosphate. The result was :—

	N.	P^2O^5.	N.	P^2O^5.
Introduced with the food in 5 days			89·8 grms.	15·95 grms.
Found in the excreta :				
Urine	83·10	10·222	94·75 „	16·907 „
Fæces	11·65	6·685		
Difference not retained by the system			–4·95	–0·957

Thus, receiving 3·8 grms. of phosphoric acid (in mineral form) more than in the preliminary period, the organism only kept 0·127 grms. (1·084–0·097) of this acid in its tissues. In another experiment, 2·966 grms. of phosphoric acid taken in the form of glycerophosphate gave almost identical results (0·136 grms. of P^2O^5 assimilated). On the other hand, when an addition was made to the food allowance of 1 grm. taken in five

[1] *La médication phosphorée*, p. 36, etc.

days of phosphoric acid under the organic form of phytin (anhydroxymethylene calcic diphosphate), the system which lost during the preliminary period 0·927 grms. of P^2O^5 gained 0·606 grms. of it (total gain : 1·543 grms.).

Lecithins give much less favourable results.

Whether it be that the phosphoric acid comes from the organic combinations in which it existed before, united with nitrogenous radicals as in the nucleins and lecithins ; or whether it comes from the oxidation of compounds where the phosphorus is still less saturated with oxygen than in the preceding products, in any case, there results from these decompositions or combustions, phosphoric acid which unites with the alkalies of the blood or of the tissues which it tends to acidify. The same formation undoubtedly takes place in the system as when we subject to rough oxidation in the muffle furnace, raised to a red heat, the phosphorated materials of muscular flesh or nerve tissue for example. Now the ash which these tissues leave, always contains a very notable excess of phosphoric acid in comparison to that which would neutralize (in the state of PO^4R^2H) the alkalies and alkaline earths present in these products. Here is an example already quoted by Liebig :—

Percentage Composition of the Ash of :	Earthy Phosphates.	Alkaline Phosphates PO^4R^2H.	Free Phosphoric Acid.
Horse flesh (Weber)	16·43%	80·96%	2·62%
Beef drained of blood (Keller) . .	26·26	48·06	17·23
Yolk of egg (Poleck)	34·70	27·25	36·74

Phosphoric acid coming from the destruction of the phosphorated principles of our tissues, is afterwards neutralized by the fixed bases of the blood, and, as has been seen, but to a smaller extent, by the ammonia which has a tendency to form in the system. These are the alkaline and ammoniacal phosphates which go to alkalize the humours of the omnivora. As for the herbivora, the organic salts with potash bases which the vegetable foods bring to them in abundance, are transformed into carbonates by oxidation, and alkalize their plasmas. Let us remark in passing that phosphates exist in the urine of carnivora but are lacking in those of the herbivora, because in the plasmas which are rich in lime and alkaline carbonates of these latter, these phosphates are carried off, or are unable to pass through the kidney. It follows that the alimentary phosphorus excreted is found again in the case of the herbivora almost entirely in the fæces.

We eliminate per day with the urine 1·70 grms. of phosphorus or 3·9 grms. of anhydride P^2O^5 of which 1 to 1·3 per cent. is

ncompletely oxidized. A great part of this phosphorus only passes through the system, entering it and leaving it in the form of phosphates. However, we have seen that in certain cases these latter may be directly assimilated in the form of alkaline or earthy alkaline phosphates.

Arsenic.—Contrary to what had been admitted up to that time, in 1900 I established the fact that arsenic enters in a very small proportion into the constitution of the ectodermic tissues: the epiderm, hairs, nails, thyroid gland, brain and breast. There are some traces of it, but much more feeble, in a few other organs. Arsenic appears to play in the system, to a large degree, the rôle of phosphorus. Perhaps it forms part of very unstable substances comparable to ferments.

Some vegetables contain very small quantities of arsenic (cabbage, radish and a few cereals). According to my researches, its most abundant alimentary source is salt, and especially the grey or coarse looking salt.

Silicon.—We do not well understand the part which silicon plays in the organism. It is found most particularly in the connective tissue. We also find it in many vegetable foods and sometimes in such a quantity that it is impossible that it should not have been selected by certain cells and play there a definite part as yet unknown. We eliminate a great deal of it by the hair of the head and by epidermic desquamation.

In the case of the herbivora, silicon is almost entirely eliminated by the fæces and hair in the form of silica.

XXX

DRINKING WATER

OF all the mineral substances which enter into alimentation, water is much the most important. It constitutes, as a matter of fact, the *milieu* where the inmost acts of cellular life are carried out. It forms about three-quarters of the weight of our organs ; it assures the nutritive changes, charges itself with the residue left by dissimilation and conveys them away. By the urine and cutaneous and pulmonary perspiration we lose every day 2,000 to 2,300 grms. of water when at rest, and 2,600 to 2,800 if we are doing mechanical work.[1]

It is necessary then incessantly to restore water to the system, which could not brook a perceptible diminution of it. Foods furnish us with a part of it (about 60 per cent.), the remainder, nearly 900 grms. to 1 litre a day, comes to us in the form of drinks We can understand then the great importance of good drinking waters.

Water is the only drink indispensable to man. Many people, the Mahometan Arabs, the Turks, Indians, Chinese and Japanese, only drink water or aqueous infusions. They none the less make prosperous races, ready for work or conquest, whose long history would suffice to show their great vitality.

Water plays in our tissues the rôle of a neutral *substratum* in the midst of which take place all exchanges. The hydration of the protoplasms is modified unceasingly, but to a very small extent.

[1] According to Petenkofer and Voit, a vigorous workman produces every day the following quantities of water (*Zeitsch. f. Biolog.* t. II, p. 480).

	In repose	At work
By the urine	1,280 . . .	1,200
By respiration and perspiration .	830 . . .	1,410
By the fæces . . .	80 . . .	90

According to C. Voit's calculations, the quantity of water formed by the oxidation of the hydrogen of aliments, represents about the sixth of the total quantity of water eliminated.

The supplies of water cause the excreta to vary; that of urea, among others, may increase in the case of man from 50 per cent. and more if he drinks a great deal; but if he continues to drink abundantly, at the end of one or two days the excretion of urea returns to its normal rate. An excess of drinking water likewise appears slightly to augment the destruction of fats (Ortel).

Water not only plays the part of appeasing thirst, it is also a food. It forms four-fifths of the weight of our tissues, and it is certain that the water in our drinks plays its part in the constitution and formation of them by its mineral salts, at least in certain conditions in an adult, and in every case in the course of the period of development of young animals.

In fact, a man from his birth to eighteen or twenty years of age, is building up his skeleton. If we reckon that flesh bone contains 36 per cent. of lime and that the mineral matters of an adult skeleton and of the soft tissues weigh about 3,000 grms., we see that a grown man has stored up at least 1,080 grms. of lime in eighteen years, that is to say, on an average 0·150 grms. of lime per day.

This is not all; the child and the adolescent lose on an average, by their urine, in twenty-four hours, 0·310 grms. of lime, and they also throw off 0·440 grms. with their excreta.[1] The daily needs in lime will be then :—

	CaO
For the formation of the skeleton	0·150
Lost by the urine	0·310
Lost by the fæces	0·440
Total	0·900

The adolescent receives daily by his average alimentation (see p. 11):

	CaO
In 260 grms. of fresh meat	0·080
In bread, 420 grms.	0·250
In dry vegetables, 60 grms.	0·135
In fresh vegetables, 250 grms.	0·300
Say	0·765

He is then obliged to borrow from water the rest of the lime which is missing, say 0·135 grms. at least, per day. But in how many cases is the food allowance insufficient and the supplies of lime less than those indicated here! In consequence, how much more pressing still is the need to find in drinking water the necessary supplement of lime.

In the course of the growing period of human life, water appears therefore to help in making up the sensible deficiency

[1] See p. 31

of the foods in lime, and probably also in some rarer mineral matters (iron, fluorine, silicon, arsenic, etc.).

For the adult, the needs are lessened since he is no longer growing. We shall have in this case :—

	CaO.	
To repair the daily loss of lime by the urine .	0·310	grms.
For the lime lost by fæcal matters . .	0·600–0·650	,,
Daily needs in lime	0·910	,,

In this case the normal alimentation (exclusive of water) provides daily, as has already been shown, the requisite quantity of lime. But if it happens to be impoverished, the adult is also obliged to borrow his lime partly from his drinking water.

The preceding calculations have been confirmed by direct experiment. J. B. Boussingault [1] took three young pigs of nearly the same weight and from the same litter. In the case of two of them which he sacrificed, he measured the lime of the bones. The third was fed for 93 days on potatoes, the lime of which had been previously measured. The animal was then slaughtered and in its bones 140 grms. more lime were found than in the skeleton of the two young pigs taken as a standard of comparison. The *solid* food taken in by the third pig containing only 98 grms. of lime, it was inevitable that the 42 grms. of excess of lime found in its bones had been furnished to the animal by drinking water. As a counter-proof this water was analysed. The lime corresponding to the total of that which had been drunk rose to 180 grms. which, added to the 90 grms. of lime of the solid foods, give the total weight of 278 grms. Now, if one adds to the weight of 140 grms. absorbed by the bones that of 116 grms. of lime contained in the total of the excrements and urine passed by the animal, we arrive at the weight of 256 grms. nearly approaching the 278 grms. of lime furnished by the total alimentation.

The 22 grms. of this base which appear to be here missing from the complete balance-sheet, correspond in reality to the lime which had entered into the constitution of the soft parts of the animal ; muscles, glands, cerebral matter, integuments, etc., newly formed.

This important experiment proves the direct utilization of one of the saline elements of drinking water, lime, even when absorbed in mineral form. But it is impossible to think that if this is assimilated, it is not the same with the magnesia, soda, fluorides, silicates, etc., which exist in drinking waters, especially since, though sufficiently supplied in our solid foods, these salts nevertheless make a necessary part of our tissues.

[1] *C. Rend. Acad. Sc.*, t. XXIV, p. 486 and XXII, p. 356.

These conclusions, however, have not been accepted by all hygienists. Some have remarked that whole populations only use for drinking waters those almost devoid of salts of lime. This opinion may be correct for a town, a mass of people living on very varied foods, and which gets an excess of salts of every kind, and in particular, salts of lime with its food ; it is not so in the contrary case. How many mountaineers drink water almost demineralized and are ricketty and goitrous ! How many populations exist on insufficient food ! How many poor people are obliged to content themselves with potatoes, vegetables and cereals often grown on silicious soils which do not bring them the quantity of indispensable salts ! How many workmen are reduced in our large towns to the strictly necessary ! For all these, drinking water must provide the necessary supplement of calcareous and magnesian salts with which their meagre daily régime does not provide them.

We shall then conclude that drinking waters, in order to be good and to satisfy in every case the general needs, should be slightly saline and calcareous.

Facts of observation corroborate this deduction. Everywhere people have always considered as the best waters for drinking those which spring from cretaceous and jurassic soils and which contain between 0·100 grms. and 0·300 grms. of calcium bicarbonate, with some other salts of which we shall speak later.

These preliminaries established, taking into account the double part which water should play as a drink and as mineral food, it is easy now for us to determine the character of good drinking waters.

Character of Good Drinking Waters.—Every drinking water ought to be fresh, limpid, odourless, slightly saline, agreeable to the taste, aerated, light to the stomach, imputrescible, suitable for the principal domestic uses.

Drinking waters are fresh if their temperature is lower than that of the surrounding atmosphere during the average seasons of the year (spring and autumn). At Paris, the average of spring is 14° ; the average of August, September and October is 15°. Water is fresh in the spring if it has from 9° to 13° ; in autumn if it varies between 10° and 14°.

The soil, at the depth of 10 metres, no longer shares in the variations of the surrounding temperature. At Paris it remains all the year at 10·8°. The result is that the water brought into the towns by pipes placed at this depth will always be sufficiently fresh.

At 5° or 6° water is cold, and not merely fresh ; its habitua use may prove deleterious.

The constancy in temperature and freshness of water from

a gushing spring is a good index of its purity. It indicates in general that this water does not receive any infiltrations from the surface soil.

The qualities of drinking waters, were they only apparent, contribute to their favourable effects. Very clear waters please the stomach and stimulate the appetite. A limpid water is one which, below a depth of 25 to 30 centimetres or more, allows us to distinguish the sharp edges and the forms of immersed objects. A slightly muddy water is always suspicious and ought to be filtered. The sediment which gives a yellowish tone to the river waters, generally contains more than 1 per cent. of organic or organized matters; these are often of the nature of microbes.

Nevertheless, limpidity does not imply purity: a limpid water may be very dangerous.

Good drinking waters have no odour. The best, when they are kept in a closed vessel nearly full, do not contract any bad smell after having been kept two or three weeks. On the other hand, water which under these conditions gets particularly thick by allowing of the deposit of yellowish, greenish, or odoriferous matters, and consequently any water which becomes putrid, ought to be thrown away or only drunk after having been subjected to filtration, or boiled or preserved several months.

Every drinkable water possesses its own distinct flavour quite noticeable to people of a delicate taste. This flavour should be fresh, without insipidity (*organic matters*), without sweetness (*alumina salts*), without taste of wet earth (*alumina*), non-selenitious (*sulphate of lime*) and without bitterness (*magnesia*).[1]

Insipidity without any special taste characterizes the absence of, or great poverty in, salts. This is the case with rain water, and with certain very pure waters coming from granites.

As we already remarked, water should be *aerated*, *light to the stomach*. Good drinking waters contain per litre from 25 to 35 cc. of gas formed by about a third of carbonic acid, the rest being a mixture of oxygen and nitrogen, in the proportion, in volumes, of 31 to 33 per cent. of the first, and of 69 to 67 of the second. The quantity of oxygen is less in spring waters at their starting point.

Aerated waters are *light* to the stomach, non-aerated waters appear *heavy*; not, as is very often said, because this want of air renders them indigestible, but because this absence of oxygen generally coincides with the presence in these waters of organic

[1] F. de Chaumont is sure that most people easily recognize the flavour of carbonate of lime in a quantity of 0·170 grms. per litre; of the sulphate in 0·36 grms.; of chloride of sodium in 1 grm. per litre. But it is one thing to distinguish such or such a salt, another thing to judge that a taste is pleasant or unpleasant.

and especially organized matters which are in process of decomposition by oxidation, and are consequently removing from the water the oxygen which they absorb and cause to disappear. These organic or organized matters, of a kind always suspicious, are unpleasant to the stomach which digests them with difficulty; hence, as a consequence, arise both the want of aeration, the sensation of heaviness of these insipid and unpleasant waters. The heaviness is not due in reality to the disappearance of the oxygen, because water boiled and cooked is not heavy to the stomach if it is of good quality perceptibly free from organic matters.

Here is, arranged almost in order of decreasing value, a certain number of waters with their contents in dissolved gas. It will be seen that their richness in oxygen is not proportional to their drinkableness.

GASES CONTAINED IN SOME DRINKABLE WATERS OF DIFFERENT VALUES

	O	N	CO^2	Total volume of gas per litre.
Spring of Duc (Jurassic soils, neighbourhood of Narbonne)	6·2	15·4	2·0	23·6
Spring of Saint-Pierre (Jurassic soils, neighbourhood of Narbonne)	5·3	15·3	9·1	29·7
Rhine at Strasbourg	7·4	15·9	7·6	30·9
Doubs at Besançon	9·5	18·2	17·8	45·5
Garonne at Toulouse	7·9	15·7	17·0	40·6
Loire at Nantes (opposite the Chateau) .	5·5	11·4	0·5	17·5
Seine at Bercy	3·9	12·0	16·2	32·1
Well, near the Saint-Honoré market-place at Paris	1·4	20·7	1·0	26·2

Although less rich in oxygen than the waters of the Rhône or of the Garonne, the two first waters are better and lighter than the river waters. We see that the oxygen diminishes in the worst of all, in the water of the Paris well.

The suitability of water for the chief domestic purposes, particularly for washing with soap and cooking vegetables, is a very good test of its drinkableness. A water which, when hot, hardens herbaceous foods by forming with the earthy bases and the legumin of these foods an insoluble compound, is a water too heavily charged with salts of lime or magnesia. It is *hard, harsh, selenitic*. These waters, poured into a limpid solution of soap, form abundant insoluble clots, and cannot any longer be utilized for soaping. Most frequently they are not very agreeable to drink, with the exception of those which, like Saint Galmier for example, are charged with an excess of carbonic acid. Still it does not suit everybody.

The waters which do not lend themselves to domestic purposes cannot be considered as capable of utilization in all cases by the populations to which they are distributed. A water too rich in iron, for example, is at once unsuitable for laundry purposes, for dyeing, for paper making, etc.; it leaves on the linen spots of iron mould and changes the colours. Too calcareous waters hinder the work of brewers and especially of dyers; they form an incrustation on steam engines, etc.

The Mineral Matters of Drinking Waters.—We have already established (p. 337) the fact that good drinkable waters are and ought to be mineralized, and that, according to the way in which we feed, they supply us daily with from 0·050 grms. to 0·150 grms. of lime corresponding to 0·090 grms. or 0·250 grms. of calcium carbonate, on an average 0·170 grms.

If, on the other hand, reasoning *à posteriori,* we examine the composition of the waters universally reputed the best, we see that the sum of their mineralizing elements varies between 0·150 grms. and 0·300 grms. per litre and that about the half of this weight is due to carbonate of lime. The following figures indicate this:—

	Fixed Residue per litre.	Co^3Ca per litre.
Water of the Rhine (before Strasbourg) . .	0·232	0·135
,, ,, Seine (above Paris) . . .	0·224	0·165
,, ,, Rhône (Geneva)	0·182	0·079
,, ,, Vanne (Paris)	0·264	0·209
,, ,, Dhuis (Paris)	0·312	0·193
,, ,, spring of Neuville (near Lyons)	0·230	0·201
,, ,, Fontfroide (Narbonne) . .	0·212	0·090

We see that the average of calcium carbonate contained in good drinkable waters approximates singularly closely to the quantity which we have shown to be daily necessary. Reasoning in the same way as regards the other salts of drinkable waters, we shall allow that those may be considered as useful, which are met with in drinking waters, reputed the best, but on this double condition: 1st, that they are found there constantly; 2nd, that these salts also constitute an integral part of our tissues.

We shall conclude then finally that the best drinking waters are those which, almost freed from organic matters, and particularly from living germs and microbes, contain from 0·150 grms. to 0·350 grms. of mineral matters per litre. Experience has shown that in the best spring or river waters these mineral matters are generally composed, per litre, of 0·050 grms. to 0·250 grms. of bicarbonate of lime with 0·005 grms. to 0·015 grms. of alkaline chlorides; 0·003 grms. to 0·028 grms. of alkaline and earthy sulphates, 0·015 to 0·050 grms. of silica, 1 to 2 milligrms.

of ferrous carbonate and finally a trace only of alumina, fluorides and phosphates.

A good drinking water does not generally leave beyond 0·500 grms. of fixed residue and does not contain more than 0·060 grms. of sulphuric acid, and 0·010 grms. of chlorine per litre.

We have recognized already the drawbacks of waters too rich in calcium, in earthy salts, in alkaline chlorides, in salts of magnesia or alumina, in earthy sulphates, etc. These last salts have the inconvenience of being reduced by contact with many organic matters which transform them into sulphurets of a disagreeable taste. On the other hand, waters containing too much magnesia are bitter and sometimes not too healthy by reason of microbes which can thrive in them.

Mineral nitrates to the extent of 0·005 grms. to 0·060 grms. per litre of water are not by themselves of any disadvantage. The waters of lakes, those which rise from primitive soils, from old sandstone, most frequently contain some of them. The best drinking waters from the jurassic, cretaceous and triassic springs can dissolve more than 50 milligrms. of nitrates per litre, when the much more impure waters of the Seine, of the Marne and of the Oise contain, on an average, only 6 milligrms. per litre. But nitrates testify no less to the initial contamination of waters by nitrogenous organic matters later oxidized by nitrous and nitric ferments. The most important consideration is that these putrescible matters should have entirely disappeared, and that one should not find in drinking waters the products of the incomplete destruction of organic substances, and especially salts of ammonia which, without being dangerous in themselves, are none the less indications of an imperfect purification of waters originally polluted.

The presence in drinking waters of salts of lead is always very dangerous. The smallest quantities of this metal ought to ensure their rejection. *Traces* of copper or arsenic would not present the same drawbacks.

XXXI

DRINKING WATERS OF DIFFERENT ORIGINS

CONSIDERED from the point of view of their drinkableness and origin, drinking waters can be classified into *running waters* and *stagnant* waters.

In the first class we include : (*a*) *Rain water* and *distilled water ;* (*b*) *Spring water* and *that of artesian wells ;* (*c*) *River* and *stream water ;* (*d*) *Mountain water* (water from snows, torrents and lakes).

In the class of *stagnant waters* we shall place : (*e*) *The water of wells, ponds and marshes.* These are generally mediocre waters.

Rain Water.—Rain water does not make a good table water. If collected directly, it only contains some traces of nitrates, sulphates, chlorides of ammonia and soda and a little dissolved air ; but the rain catches the dust of the air and with it innumerable microbes. If collected on roofs and kept in a cistern, being charged with the castings of birds, germs of moulds and bacteria, this water is putrescible and often dangerous to drink, at least if it has not remained some months in a cistern where it gets purified. Moreover, it is liable to come in contact with the lead and zinc of the covers and metallic solders of the roofs, to attack them and to hold a little of these metals, etc. Rain water then should be most frequently regarded with suspicion. Nevertheless many towns, Venice, Cadiz, Vanne, Cette, Neubourg, a great part of Constantinople, etc., only drink rain water, but rain water which has been kept in covered cisterns, sunk into the ground, where the water has time to purify whilst sheltered from the dust and light.

Distilled Water.—Distilled water, to-day in current use on long distance ships, is procured generally from the distillation of sea-water. It can be drunk without inconvenience provided that it has been distilled in an apparatus of copper plated with *pure tin*,[1] and kept in reservoirs of wood, or sheet iron galvanized with zinc free of lead. Waters deprived of all nauseous tastes are obtained by distilling them in the presence of a slight excess of permanganate of potash or lime, to oxidize the organic matter.

Spring Waters.—Spring waters, especially those which come from deep levels, the temperature of which is nearly invariable all

[1] It should not contain more than three to five ten-thousandths of lead.

the year, and lower at least by some tenths of a degree than the average annual temperature of the air in the locality, are the best drinking waters.

Springs which rise from granite soils leave only a small residue (0·007 grms. to 0·030 grms.) of salts per litre. They are usually good waters but poor in mineral substances.

It is from the silurian, devonian, jurassic and cretacean soils that the best drinking waters come ; they are not however all irreproachable. These waters leave, per litre, from 0·150 to 0·500 grms. of fixed residue (corresponding to 10 to 20 French hydrotimetric degrees) half of which residue is formed of calcium bicarbonate. Their mineral elements are generally in good proportions. Those whose temperatures vary less than 1° from summer to winter, have also a very nearly constant composition and are the purest. But in soils with much cracked strata, such as the cretaceous and overlying series (myocene and pliocene, etc.), it is rarely that spring waters are entirely free from organic matters and even from microbes originating from arable soil.

Here is a table of the composition of some types of spring waters :

Analyses of Different Types of Good Spring Waters.[1]

	Saint-Martial (Granite).	Chalet du Compas (Granite).	Font-froide (Jurassic).	Vanne at Mont-souris (Cre-taceous).	Marly-les-Valen-ciennes (Chalk).	Saint-Clement (Pliocene).
	grms.	grms.	grms.	grms.	grms.	grms.
Carbonate of lime	0·0002	0·012	0·088		0·254	0·275
,, magnesia	—	—	0·014	0·113	0·018	0·032
,, protoxide of iron	0·0002	—	0·001		trace	0·002
Chloride of sodium	0·0018	—	0·052	0·008	0·018	0·023
,, calcium	—	0·007	—	—	—	—
,, magnesium	0·0054	—	—	—	—	—
Sulphate of potassium	—	—	0·0006		0·0015	0·002
,, soda	—	—	0·0058		—	—
,, lime	0·0013	—	0·036	0·136	0·004	0·012
Silicate of lime	—	—	0·007		—	—
Alkaline silicates	0·0119	—	—		—	—
Silica	0·0030	traces	—		0·011	—
Phosphoric acid and alumina	0·00004	—	0·009	—	trace	—
Iodides, bromides	trace	—	trace	trace	—	—
Nitric acid		—	trace	0·0025	0·029	—
Organic matters	trace	—	0·0005	0·004	0·018	—
Total residue per litre	0·0238	0·019	0·214	0·263	0·349	0·346

[1] *Water of Saint Martial.*—From granite in the neighbourhood of Limoges. Good drinking water entirely free from nitrates and organic matters. Analysed by the author.

Water from the Chalet du Compas.—Greatly esteemed, springs from a

As long as the surface of the ground remains turfed or covered with wood, infiltrated waters and the springs which come from them, vary little. On the other hand their composition becomes variable, at least in the case of cretaceous and overlying soils if the state of vegetation, clearing of woods and cultivation change.

When the composition and temperature of the waters of a spring remain constant, summer and winter, it is because it does not receive, as a rule, any admixture of rain-water. In this case contaminations of superficial origin are much less to be feared. The existence in spring waters of ammoniacal salts, the increase of sulphates, a rise in the number of microbes are the most sure signs of these temporary pollutions.

Waters which come from gypsous soils containing salts, anthracite, pyrites or which are too rich in mould, those which come from the most modern quaternary soils, those whose temperature and composition are variable and those which contain ammoniacal salts, are bad spring waters.

Waters from Artesian Wells.—Waters from artesian wells are, properly speaking, waters from artificial springs. In the same place they may sometimes differ in composition according to the depth of the bed which furnishes them. Indeed, if these beds are much inclined, the composition of the water of two wells very near together may be quite different. This is the case in the wells of Robert and Bellonet in the citadel of Calais. The water of the first gives 2·51 grms. of fixed residue per litre, that of the second only 0·58 grms.

River or Stream Waters.—River or stream waters have for their origin, on the one hand, spring waters, on the other the streams from mountain rains, the melting of ice and snow. Their composition varies therefore in their course and changes perceptibly with the seasons, rains, dryness, tillages crossed, etc. Thus the fixed residue of the water of the Rhône falls from 0·18 grms. to 0·10 grms. per litre when the snow melts.

Rains, by washing the arable soil and that of towns, afterwards pollute the water of rivers where they flow away. They are charged, in the fields and cities, with matters undergoing decom-

primary rock at the foot of the great Charnier (Isère). Analysed by Nièpce.

Water of Fontfroide.—Excellent drinking water from the jurassic soils in the neighbourhood of Narbonne. Analysed by the author.

Water of Vanne, greatly esteemed, excellent taste, from cretaceous soils. 11 milligrms. of oxygen dissolved in 100 cc. CaO = 112 milligrms. (Analysis of the water from the reservoir of the Vanne) (Laboratory at Montsouris).

Water of Marly-les-Valenciennes.—Water very limpid, agreeable flavour, good water coming from chalky soils.

Water of Saint-Clément.—Reputed excellent. It rises in the neighbourhood of Montpelier from pliocene soil (Analysed by Rousset).

position and with innumerable germs. They become enriched with sulphates, phosphates, nitrates, chlorides, ammoniacal salts, organic matters and carbonic acid, and lose part of their oxygen. To all these causes of inferiority of river waters are added those which result from the variations in the water levels, from overflows and muds which they carry away, from their flow in the open air which gives its dust to them, and from the enormous variations in temperature and supply of the waters at the different seasons. This shows that in almost any case it would be unwise for a big town to obtain its drinking water directly from the river which runs through it.

After being polluted in the towns, the action upon the water of streams by air and light, eliminates in a long course the most numerous and dangerous microbes ; the water is aerated little by little and becomes again, fairly rapidly, good to drink. During the passage of the Seine through Paris, the number of microbes which had risen per cubic centimetre from 11,500 at Melun, before the great city, to 2,512,000 after having received the drains of Paris at Saint Denis, falls at Mantes, at the end of only 80 kilometres of its course, to 277,500 (Miquel). The water of the Wüpper, near Berlin, repulsive with filth at Elberfeld, becomes limpid again at Opluden, some miles farther on.

The oxygenation of the water is besides in inverse ratio to its pollution. Here are some figures due to Milter ; they relate to the water of the Thames above and below London :—

	CO^2	O	N	Proportion $\frac{N}{O}$
Kingston	30·3	7·4	15·0	1 : 2
Hammersmith . . .	—	5·1	15·1	1 : 3·7
Greenwich	55·60	0·25	14·5	1 : 60
Erith	57·0	1·8	15·5	1 : 8

For the Seine the dissolved oxygen has been found, per litre (Gérardin) :—

At Corbeil, above Paris	9·32 cc.
At its entrance into Paris	8·05
At Auteuil, above the main drain	5·99
At Epinay, below the main drain	1·05
At the bridge of Poissy (about 60 kilom.) . .	6·12
At Mantes (about 80 kilom.)	8·96

In these waters, defiled by the débris of towns, ammonium may be produced, and, in presence of the carbonic gas of the air, cause the lime to partly disappear, precipitating it in the form of insoluble carbonate, whilst sulphuretted hydrogen and putrid odours are developed. However, after a course of 50 to 80 kilometres, these waters again become drinkable.

Here are, as examples, some analyses of the waters of rivers due to M. Ch. Ste-Cl. Deville :—

COMPOSITION OF THE WATER OF DIFFERENT RIVERS (PER LITRE)

	Loire (above Orleans).	Garonne (above Toulouse).	Rhône at Geneva (above the Arve).	Seine Bercy (beginning of Paris).	Rhine Strasbourg (May).	Danube (above Vienna).
	grms.	grms.	grms.	grms.	grms.	grms.
Calcium carbonate . .	0·048	0·064	0·079	0·166	0·136	0·086
Magnesium ,, . .	0·006	0·003	0·005	0·003	0·005	0·013
Soda ,, . .	0·014	0·006	—	—	—	—
Carbonate of manganese	—	0·003	—	—	—	—
Chloride of soda . .	0·0048	0·0032	0·0017	0·0123	0·0020	0·0033
Sulphate of potassium .	—	0·0076	—	0·0050	—	—
,, soda . .	0·0034	0·0053	0·0074	—	0·0135	—
,, calcium .	—	—	0·0466	0·0269	0·0147	—
,, magnesium	—	—	0·0063	—	—	0·0164
Nitrates	?	?	0·0085	0·0146	?	?
Silicic acid	0·042	0·0085	0·0238	0·0508	0·002	0·002
Alumin	0·0071	—	0·0039	0·0005	0·0025 }	0·002
Peroxide of iron . . .	0·0055	0·0031	—	0·0025	0·0058 }	
Dry residue	0·1346	0·1367	0·1820	0·2544	0·2318	0·1414

Waters of Canals, Ditches and Drains.—Canal waters are generally borrowed from rivers or come, like the Canal du Midi, from the gather of brooks and mountain torrents. By reason of their smaller supply and origin, these waters share in all the drawbacks of those of streams and rivers. Even more than the latter, they are liable to be polluted by industrial refuse, washing of linen, and drain waters.

The *waters of ditches, channels and drains*, formed by waters which have passed over arable soil, are always very bad drinking waters.

Waters from Rain, Snow, Lakes and Marshes.—Mountain waters have their origin in the rains which stream down over the soil and the waters which are formed by the melting of the ice and snows.

The rains of high regions differ from those of the plains in the small proportion of microscopic organisms that they bring down. The air at 2,800 metres only contains 6 to 10 bacteria per cubic metre instead of 480 in the plain ; but life is everywhere, even at these altitudes, and organic detritus is met with in these waters as soon as they have flowed over the soil. Snow catches, whilst falling, all the small bodies floating in mountain air. Thus the microbes are removed on the surface of the glaciers, whilst the deepest bed melts and the mass of ice, by slipping over the rock and wearing it, forms the muddy torrent which emerges from

it at the base of the valley. In studying the melted waters of the large glacier of Jostedalsbru in Norway, Schmelck found, per cubic centimetre at 1,800 metres, only 2 living microbes ; in the water of a stream which came from it, 9 to 15, and at 5 kilometres beyond that, 170 to 200 microbes per cubic centimetre of water. The most abundant of these organisms was the *bacillus fluorescens liquefaciens.* The majority of the other microbes on the surface had been killed by the prolonged action of cold.

Mountain torrents have then for origin, rain water and that which comes from the melting of glaciers. These waters, very poor at the beginning in saline materials, are enriched at the expense of the rocks over which they pass, in silicates, sulphates of lime, magnesia, chlorides, organic materials and gas from the air, and go to form lower down rivers or lakes.

Thus formed the water of lakes rapidly becomes clear by settlement ; it becomes limpid, if not always healthy to drink, having very often received excreta from flocks living on the mountain. But these waters may become good when they become running. Chicago takes its drinking water from Lake Michigan, Boston from Lake Cochituata and Edinboro' from Lake Katrine. The waters of Lake Geneva, through which runs the Rhône, are sufficiently pure.

It is not so in the so-called lakes of the plains, such as that of Grandlieu, in Loire-Inférieure, basins without perceptible flow which are ponds or marshes rather than real lakes.

Those ponds which receive and retain rain water in the most sloping parts of the large plateaux, unfortunately form the only drinking water of large tracts of country—Sologne, Bresse, and the country of Caux in France for example. These are nearly always very bad waters. Innumerable bacteria multiply in them, absorb their oxygen, reduce their sulphates and may even make these waters ammoniacal. The elevation of temperature helping, a crowd of animalculæ, larvæ, etc., live there, die and putrefy there, communicating to them that nauseous taste of marshy waters that one cannot drink without disgust, and often without danger, unless previously boiled.

Well Waters.—These waters are of two kinds : sometimes the wells are dug near dwellings ; real upright drains, they gather the filtrations of the surrounding soil. These are bad or dangerous waters. Sometimes the wells are in the open country ; they penetrate through the permeable beds as far as the clayey layers on which rests the sheet of subterranean water which runs through the subsoil. As a kind of artificial spring, these wells can furnish good drinking waters. However, the sheet of water being near the surface of the earth, they are liable to all the objections raised earlier against waters from too superficial springs.

Wells dug in the middle of towns most often only provide danger-

ous waters, such as the wells of Rodiz, Laon, Rheims, real sources of goitre, and the water of the wells of Munich, Paris, etc., which may transmit typhoid fever. In these waters the weight of nitrates sometimes exceeds 1 grm. per litre and that of dissolved animal matters, originating from the ejections of man and animals, may rise to 0·10 grms. Living micro-organisms multiply there owing to the incessant renewal of organic matter, to ammoniacal salts and nitrates.

Table Mineral Waters—Natural or Artificial Ice.—Amongst the mineral waters which are drunk as table waters, we shall quote in the case of France: Saint-Galmier, Morny-Chateauneuf, Condillac, Saint-Pardoux, Vernet (Ardeche), Chateldon, etc.; of Westphalia, Pyrmont; of Alsace, Soultzmatt; of Nassau, Seltzer, etc. These waters are sometimes acidulous and calcareous, sometimes acidulous and alkaline with a predominance of free carbonic acid. Very poor in organic matters, piquant to the taste, they are usually agreeable and facilitate digestion. But the habitual use of them should not be recommended, whether because the continued action of gaseous carbonic acid on the stomach is hurtful, or because the superabundant salts of lime fatigue the kidneys and bring on oxalic or phosphatic gravel in persons predisposed that way. With these natural gaseous waters, we must place waters artificially charged with carbonic acid, called *artificial seltzer water*. They have various disadvantages; the chief is that they are very often made with river and well waters which have not been filtered, and are in consequence dangerous. They may also contain traces of salts of lead in suspension, as I have proved. This drawback has been much diminished since the new method of manufacture consisting in the injection of the carbonic acid into the syphons themselves. But this latter system has the disadvantage of allowing the bottles, which pass from hand to hand without other cleansing, to be washed only under great difficulties.

Iced water is much sought after, especially in the summer. Unfortunately the ice itself is generally introduced into the glass. Now, whether natural or artificial, the ice employed in drinking is not always healthy. It contains, more or less, the impurities of the waters which have produced it. Some beautiful natural ice sold by a Parisian company, ice originating from the ponds of Briche, of the Bois de Boulogne and of Chaville near Paris, gave the following results[1]: a litre of water melted from this ice[2] evaporated under shelter from the dust of the air, left 0·125 grms. of mineral salts. This residue was found to be nitrogenous, it set free ammonia when treated with alkaline carbonates, it gave the characteristic reactions of nitrous and nitric acids. Under the

[1] A. Biche: "Rapport au conseil d'hygiène et de salubrité de la Seine."

[2] The melting of large blocks of very transparent ice, previously washed on their surface with distilled water.

microscope it was observed to contain a large quantity of microbes and vibrios.

Following a grave epidemic of diarrhœa, James Carder, examining in 1875 the ice of Rye Beach, near New York, seeing the amount of microbes in it, brought about the prohibition of the use of ice from Lake Onondaga for alimentary purposes. Frankel and Prudden in the ice of river and pond waters, also noticed several thousands of bacteria per cubic centimetre. Lastly, H. Anton and Rieder established in 1888 the fact, that many saprogenetic or pathogenetic microbes can be kept for a very long time in ice without losing their vitality or their virulence (*Instit. imp. d'hygiène*, Berlin 1888). These experiments have been carried out again and confirmed in Paris by MM. Chantemesse and Widal.

Ice directly consumed on our tables should thus only be considered healthy if it comes from boiled, or at least very carefully filtered water.

XXXII

DISEASES ATTRIBUTABLE TO DRINKING WATERS—PRESERVATION AND PURIFICATION OF DRINKING WATERS

TO conclude the study of the various drinking waters, we must ask if any diseases exist and are transmissible by drinking water; if there are any relations between the state of deficient health or the endemic diseases which affect certain populations, and the nature of the waters which they drink.

We shall afterwards treat of the purification of unwholesome waters.

Diseases Attributable to Drinking Waters.

Rickets, scrofula and tuberculosis perhaps appear to proceed from the invasion of the individual by organisms of decay as soon as the tissues are no longer protected by assimilation of sufficient lime, magnesia, iodine and arsenic, an assimilation which good drinking waters help to achieve. In spite of their small proportions the constant presence of certain elements of which we find traces in our organs, arsenic, bromine, iodine, copper and manganese in particular, leads one to believe that these elements play an indispensable part, and that in consequence, the small quantity which water furnishes of them cannot be neglected. Nevertheless, the importance of infinitesimal quantities ($\frac{1}{200}$th of a mgr. per litre) of iodine for example, in the waters of healthy countries, does not appear to have been sufficiently demonstrated even when this non-metal disappears totally as it seems to do from the waters of countries where goitre prevails (Chatin).

When drinking waters are too rich in sulphates, bi-carbonate of lime, or in alumina salts, they get an earthy flavour which upsets the stomach. Sulphates entering in abundance into the alimentary canal may there be partly reduced to the state of sulphides and of sulphurets, salts which are far from being harmless, even in a small quantity.

Since Hippocrates, physicians have charged waters which are too chalky with favouring the formation of urinary deposits. People suffering from calculus are, it appears, relatively numerous in the suburb of Avignon, called *The Isle of Vaucluse*, where they drink the very chalky water from the

fountain of that name, as well as in the country which receives the same waters, even when such cases are said to be rare in the rest of the town and country. In the same way, since the substitution of mountain waters for the too chalky waters of the Clyde, vesical calculi, formerly very frequent in Glasgow, have progressively diminished. The same facts are said to have been noted at Paisley, Bolton and other English towns.

The presence of nitrates in waters, even to the amount of 0·350 grms. per litre would not be alone too injurious, if these salts were not the sign of original pollution of these waters by nitrogenous ejections.

Of all the dangerous mineral substances that one may accidentally find in drinking water, lead is the most formidable. It may be introduced by pipes, reservoirs, solder and the metallic roofs of our dwellings. Natural waters charged with sulphates and carbonates do not attack lead much, but rain water, distilled water and water which contains chlorides, nitrates and certain organic matters dissolve it much better.

In this respect here are some interesting experiments by P. Coulier. He plunged sheets of lead with a surface of 16 square decimetres in some glass receivers each containing 2,400 cc. of water half saturated with each of the salts indicated below. The evaporated water was replaced from time to time by its volume of distilled water. He observed that the sheets were attacked slowly and that they had undergone losses and alterations to the extent indicated in the following table :—

	Loss of weight in milligrams.			Observations made after 8 years.
	after 64 days.	after 5 years.	after 8 years.	
Distilled water . .	1·8	60·1	58·9	Purple tint. The sheet is reduced to fragments.
Water of the Dhuis .	0·50	0·60	0·70	Sheet is coloured brown with fern-shaped designs.
Water of the Seine .	0·15	0·70	0·16	Sheet eroded in parts.
Distilled water and carbonate of lime	0·35	0·10	1·05	Sheet intact. Uniform brown tint.
Distilled water and sulphate of lime	0·30	0·80	0·80	The sheet has assumed a whitish tint.
Distilled water and salt	1·00	12·40	13·9	Brown tint, sheet perforated where bent.

We see, therefore, that pure waters are really those which attack lead best.

The best known example of lead poisoning through drinking water containing lead is that which in 1853[1] attacked the

[1] Gueneau de Mussy (*Ann. d'hygiène et de méd. légale*, 1853, t. IV, p. 318).

Orleans family at Claremont. The spring water which before reaching the castle had passed through leaden reservoirs and conduits contained, according to the analysis of W. Hofmann, 4 millgrms. of this metal per litre. Thirty-four persons out of 100 were attacked. The children resisted much better than the adults.

I have myself made numerous researches into the conditions which introduce lead into our drinking waters.[1]

By remaining some days or some hours in contact with new lead pipes, spring waters or river waters become charged with about half a milligrm. and more of lead per litre. In old pipes, even when covered on the interior with a calcareous crust, they still take up a little lead partially dissolved, partially in suspension. These lead incrustations of the pipes are detached on the least effort. They may contain as much as 50 or 75 per cent. of lead.

The simple flowing through the leaden branch pipes which pass from the streets into dwellings does not introduce into these waters any ponderable quantity of this metal. But for the general distribution of the waters of a town, particularly when they have little lime, we must give up leaden pipes and have recourse to earthenware, to iron tubes or to lead sheathed with pure tin.

The Influence of Organic Matters of Drinking Waters.—The ordinary organic substances of drinkable waters, matters called humic, unless they are very abundant, need not be feared. Waters which are contaminated with them are sometimes disagreeable to drink, they have a taste of mud, but they are not particularly dangerous. We only know that the yellowish water of rivers and the waters of muddy soils are slightly laxative. This is very often their only disadvantage.

Certain drinking waters seen in mass appear coloured ; those of rivers which water the high plateaux of South America, show, in certain cases, a blackish tint which they owe to an acid humic matter borrowed from the granitic soils which they traverse (Müntz and Marcano).

Nevertheless the populations of these countries prefer these black waters to the white waters of the same regions.

The real danger of drinking waters lies above all in the lower organisms which can live there. They come, in a large measure, from the excrements of animals and human beings. Without doubt, pathogenic bacteria are frail and only multiply with difficulty in waters already inhabited by harmless microbes (Meade, Bolton) ; but they may still multiply there. In 1887 Messrs. Chantemesse and Widal found the bacillus of typhoid living and cultivable in the water of the Seine at Paris.[2] The

[1] See my book : *Le cuivre et le plomb dans l'alimentation et l'industrie* (Paris 1853, p. 152 seq.).

[2] *Arch. physiolog.*, April 1887.

comma bacillus of cholera was discovered in 1884 by R. Koch in the water of the ponds of India where thousands of other microbes abounded. That of the septicæ was taken by G. Gaffky from the waters of the Spree at Berlin. Nevertheless as Bolton, Karlinski and then Dubarry have shown, pathogenic bacilli disappear fairly rapidly from river waters owing to the harmless bacteria which live there. These rapidly suppress the bacilli of cholera, anthrax and yellow fever. Whilst in spring or stream water, previously *sterilized*, Dubarry again found the bacillus of anthrax living 131 days after he had introduced it there, and that of typhoid fever 81 days after, the first disappeared after 4 days, the second after 2 days, the cholera bacillus after 1 day, if the cultures of each of these microbes were put into the same *non-sterilized* waters.

These facts and the history of epidemics show the possibility and the reality of the transmission of typhoid fever, cholera, yellow fever, etc., by drinking waters. We even ought, we think, to add the transmissibility of malaria by marsh water outside of the ordinary inoculation of the specific hæmatozoa by the stings of the anopheles. Finally, it is almost certain that waters are the means of carrying and transmitting dysentery. From 1869 to 1873 the deaths attributable to this disease rose, in the capital of Austria, to 84 a year. From 1874 onwards, the time when mountain waters were substituted for those of the Danube, the annual mortality from dysentery fell to 12. To-day it has almost entirely disappeared.

Endemics of goitre and cretinism have been attributed from all time to the use of unhealthy waters. They have been successively accused of too much freshness, want of aeration, richness in magnesia, lack of iodine, decomposed organic matters, etc. I have previously criticized these opinions which are all ill founded.[1]

As the result of an inquiry which lasted nearly twenty years, Mgr. Billat, Archbishop of Chambery, arrived in 1850 at his remarkable conclusion *that endemic goitre is brought about by a miasmatic cause which is produced in certain soils, especially in magnesian soils rich in organic matters in course of putrefaction, miasmas which communicate to the waters their toxic properties.* In a word, as we should say to-day, the cause of this affection is attributable to a microbe, still unknown, breeding particularly in magnesian soils from which the drinking waters take it.

We ought further to point out here the protozoas and entozoas which, in the state of eggs or larvæ, are carried by drinking water ; the eggs of the bothriocephalus and tœnia, ascaris lumbrie coidis, etc. ; the ambœa of the diarrhœa of Cochin

[1] *Les eaux potables ;* J. B. Baillère, publisher, Paris 1863.

China, bilharzia of Egypt and of the Cape, the distoma hepatica, filaria of the blood, etc. But in a book on alimentation it is not possible to enlarge, even incidentally, on this important branch of special pathology.

DISTRIBUTION OF DRINKING WATERS; QUANTITIES NECESSARY.

If it is a question of an urban population, of the choice of new sources, of the construction of cisterns or of basins, etc., the first question which always presents itself is that of the quantity of water which may be necessary per head per diem. This question admits of many solutions: from the strict point of view of daily needs, we may say that for personal toilet purposes or for the use of the house 100 litres of water are strictly sufficient per head daily. If it is a question of the needs of a town, with its watering of streets and gardens, its steam engines, its lifts and other hydraulic machines, its industries, etc., it seems that 150 to 180 litres are indispensable daily for each inhabitant. According to Graham, 128 English towns receive on an average 142 litres per head daily; Paris 250 litres; Toulouse 160; New York 300; Dijon 150. But with its monumental fountains and its waters gushing in almost every house and at each cross-way, ancient Rome used to distribute 2,000 litres of water daily to each of its inhabitants.

Conduits, Reservoirs.—Drinking waters should be brought to towns by round pipes or covered channels. They may be made of pottery, of cemented masonry, of cast iron lined or not with coatings into which tar, asphalt, etc., enter, but never of lead. The reason has been given before (p. 353).

Urban reservoirs are generally of concrete covered with hydraulic cement well smoothed. The best are those which are sunk for several metres in the soil or which have been hollowed out in the rock. Every reservoir of water ought to be covered, and if possible underground.

Purification of Waters.—Water unfit to drink may be thick, muddy, contaminated with organic and organized matters. It may contain salts in excess. A different method of purification is suitable in each case.

There are very few waters which can be drunk without having been previously clarified in the large reservoirs of towns. It is only at the end of from eight to ten days that the muddy water from rivers becomes almost clear there.

This purification by deposit can only be viewed as a first rough treatment. Indeed microbes only disappear from these waters at the end of several weeks. It becomes necessary then, in almost every case, to complete the purification by a careful filtration.

This may be done either in the separate households by means

of domestic filters or by the authorities for the needs of the whole town.

A large number of systems of filters intended for separate households have been proposed.

The simplest consists of a large sponge, well washed with hydrochloric acid at 2 per cent., which is forcibly pressed down to the bottom of a cast-iron cylinder, or if need be of an earthenware pipe, pierced with a hole in the bottom. Half the cylinder is then filled with well washed sand. The water poured in passes through the sand and the sponge for a distance of 20 to 40 centimetres, depositing there a large part of its impurities. At the end of some days the sand is choked with the ordinary bacteria of water. The filtration then proceeds more slowly but the water passes through with its dangerous impurities perceptibly lessened. This filter has the advantage of being able to be made quickly and almost anywhere.

An iron or wooden cask may be used, at the bottom of which one or two sheets of flannel or of well washed felt are placed; it is then filled with pebbles and fine sand interspersed with layers of charcoal and scraps of iron. A lateral tube, running to the bottom of the cask allows the air drawn in by the water to escape from the top of the filter.

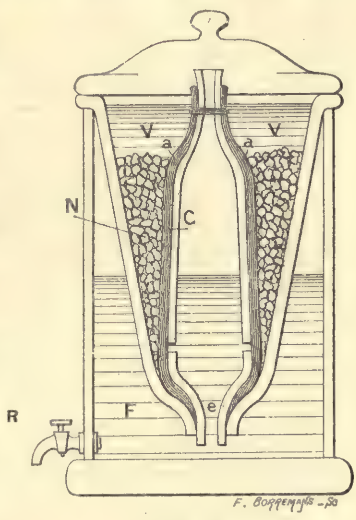


Fig. 9.

In the preceding filter the sand may be replaced by bone charcoal. The trade thus constructs some very good charcoal filters. One kind is formed by an agglomerated block, dense but porous, furnished with a central tubular hole to which is fitted an india-rubber tube which acts as a syphon. This block of charcoal being plunged in the water to be filtered, suction is made at the outlet of the india-rubber enabling the water to flow and so become purified while passing through the filtering cylinder.

The following apparatus (Fig. 9) is preferable:

Out of a thick asbestos cloth is made a kind of accordion pocket of a double cone *a a e*, supported in the interior by a shell C of stoneware pierced with holes in the base and terminating in an outlet *e* which serves for the water to escape. This apparatus

is placed in a cylindrical stoneware jar, V, the lower tubulature closed by a cork through which the outlet *e* passes. This jar V is itself placed in the centre of a reservoir F provided with a cover, and at the foot with a tap R. In the central jar V, between its walls and the filtering asbestos cone, is placed a layer of 30 and 40 centimetres deep of black animal charcoal partly grainy, partly pulverized, which fills it almost entirely ; on this the water to be filtered flows from above. It passes through the charcoal which it is not slow in inundating, then through the thick asbestos cloth and passes by the holes of the lower part into the central cone whence it goes to the reservoir F which it fills. The filtered water is collected by the tap at the foot.

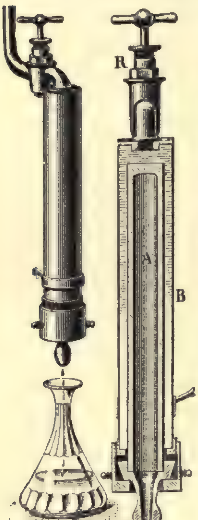


FIG. 10.
CHAMBERLAND
Porcelain Filter.

This filter, especially when it has been in use several days and is working well, causes the greater part of the pathogenic microbes which flow in it to disappear. It absorbs wholly or in part metallic salts of zinc, lead, etc., which the water may contain in a small quantity. It deprives it of a part of its lime and magnesia, of all its iron, and of a notable quantity of its organic matters, etc.

Everybody knows the ordinary filter of the Parisian households. It is formed by a reservoir of limestone and of sandstone separated into two compartments of unequal heights by means of a thin inclined sheet formed of a porous stone and bound to the vertical walls by a special cement. The water which fills the fountain passes through this stone diaphragm at a slight pressure and deposits its mud and microbes on the surface. When this filtering partition is intact and well cemented we may reckon on the purification of the water. It is only necessary to rinse out the apparatus from time to time and to gently scrape the upper face of the filtering stone.

In 1884, I invented the filters of unglazed porcelain or earthenware for the purpose of sterilizing water and culture liquids.[1] The filter called *Chamberland* (Fig. 10), which came after mine, consists of a tube of unglazed porcelain enclosed in a metallic mandrel, porcelain which the water traverses from the exterior to the interior. It gets rid of the greater part of its impurities on the filtering partition. These filters of porcelain paste incompletely baked have rendered real service, but they are far from

[1] See *Bull. Acad. méd.*, t. XI, pp. 314, 352, and *Bull. Soc. chim.*, t. XLVII, p. 146, June 1884.

presenting every guarantee of safety. The public demands, and trade provides it with more and more rapid filters. This apparent quality is only obtained by giving to the porcelain partitions more and more thinness and porosity.

By the passage of the water, the porcelain at the end of a certain time disaggregates, its openings continue to increase instead of diminishing, and the rate of filtration increases more and more. My first observations on this subject, confirmed by MM. Bourquelot, Galippe, Villejean and Miquel in France, and Wolfhügel and Riedel in Germany, have proved that several pathogenic or saprogenic microbes pass by degrees across these porcelain filters or penetrate into their partitions by their mycelia which traverse them.

Attempts have also been made to replace unglazed porcelain by unglazed asbestos of a much closer and more efficacious grain. Generally the water to be filtered first passes into a cylinder of rough porous charcoal to pass afterwards across the partition of unglazed asbestos.

When it is a question of purifying the water of an entire town, the preceding filters are insufficient, or at least cannot be looked upon as being destined to complete the purification of the water distributed in each house by the town pipes. Generally the water of towns is first purified by deposit in large reservoirs if it is a question of spring water, or by filtration through the soil if it is a question of that of streams and of rivers. The type of these last filters was that which was made at Toulouse in the eighteenth century by the engineer D'Aubuisson for the waters of the Garonne. By means of a series of galleries, the water of the stream traverses by its own weight a natural bank of sand and of pebbles formerly deposited by the Garonne. It is then collected in galleries of dry stone, the floor of which is 4·30 m. below the level of the soil and 1·10 m. *above* the level of the water of the surrounding wells. This latter condition protects the water received in the galleries from the infiltration of the waters of the subsoil, which are always infected by the refuse and detritus of the town.

Since then, filtration of river water through sandy soils has been adopted at Warsaw, Berlin, Calcutta, Hanover, Strasburg, London, etc. At Berlin the waters taken from the Tegelsee, from the Rummelburgersee and the Spree, first drop their mud in some large basins where they stay twenty-four hours. They are then filtered across layers of gritty pebbles the grain of which constantly diminishes down to fine sand. The thickness crossed is 1·40 m. Waters thus treated should not contain more than some hundreds of microbes per cubic centimetre. The greater part have been arrested or destroyed by means of the action of the sandy layers inundated by deposit of very active zooglœa.

The soil possesses a marvellous power of destroying microbes, but on condition of there being no large fissures and of the water filtering regularly and slowly from layer to layer. When it is a question not of filtering river water, but of purifying sewer water, the speed ought to be such that through a layer of 2 metres thick not more than 15,000 to 20,000 cubic metres per hectare run per year. A surface of 1 metre square should not then give more than 5 to 6 litres of water per day. In the experiments made by D. Miquel for the town of Paris the water yielded per cubic centimetre :—*Rain water*, 35 microbes *waters of the Vanne*, 62 ; *waters of the Seine*, 1,200 ; *sewer water*, 20,000. The same *sewer water* on leaving the drains of Gennevilliers, after having filtered across the soil at the above-named speed, did not contain more than 24 microbes. R. Koch, at Berlin, has found : *Boiled distilled water*, 4 to 6 colonies ; water from the Rummelburgersee, 32,000 ; sewage water, 38,000,000. In the same sewage water on leaving the drains of Osdorff, 37,800 were found—that is to say, a thousand times fewer.

But for the filtration of drinking waters taken from rivers, generally sand filters 1·50 m. and even 50 centimetres thick, are considered sufficient, and the water is made to pass through at a speed of 15 centimetres per hour. Wibel has noticed that after this rapid filtration, water from the Elbe at Hamburg loses 34 to 61 per cent. of its dissolved matters and 64 per cent. of its organic substances, but the micro-organisms and their germs pass through in part, and it is necessary before drinking these waters to purify them again by good domestic filters.

We have remarked before that these last, even the most perfect, do not arrest the whole of the dissolved organic matters or even all the microbes. To effect a complete purification one may have recourse to two methods : chemical actions or heat.

Many means of purifying drinking waters chemically have been extolled. The most practical are : the use of permanganate of lime or potash, ozone or peroxide of chlorine.

The permanganates of potash or of lime should be added to the water until it remains slightly pink. It can then be filtered on charcoal. The organic matters, the microbes are in a large measure oxidized or destroyed by this process.

Ozone also appears to be a good sterilizer of drinkable waters in the quantity of 6 milligrms. per litre, provided that its action be sufficiently prolonged and that the waters are not too rich in organic matters. Only the *bacillus subtili* would partially resist. Some experiments made at Lille by MM. Roux and Calmet have partly verified these results.[1]

Peroxide of chlorine, ClO^2 has also been commended for steriliz-

[1] See *Journ. pharm. et chim.*, June 1, 1899, p. 552.

ing drinking water. It would act sufficiently in the proportion of 1 grm. per cubic metre of water. It is obtained by the action, when cold, of sulphuric acid at 28° Beaumé (3 parts H^2SO^4 and 1 part water) on chlorate of potash. The action of this gas ought to be prolonged for some time in order to be efficacious. There are other methods of chemical purification of drinking waters which allow us to do without filters, which we cannot have everywhere, and which deprive the water of the substances which make it muddy or render it undrinkable, and at the same time of a large part of its micro-organisms. If the water is impure from organic matters it can be cleansed with slaked lime, with pipeclay, etc., a little alum may be added, then a little milk of lime. At the end of thirty-six to forty hours, the water is cleared and the precipitate has carried off nearly the whole of the suspicious matters.

If the water is too selenitic, two thousandths of carbonate of soda may be added to it, or a little lixivium of wood ash which precipitates the lime to the state of carbonate. If it is overcharged with magnesian salts, like those of the African chotts, it is treated with a slight excess of clear whitewash : the liquor having become limpid, it is decanted and shaken in the air in order to finally render insoluble by carbonic acid the traces of lime which have remained in solution.

Of all these processes of purification, including the careful filtration of water, none equals purification by heat or distillation. Water boiled *for some minutes* may be considered as absolutely inoffensive : whether it is drunk after cooling in the air, where it becomes sufficiently aerated, or whether it is absorbed in the form of infusions of very weak tea or coffee. The inhabitants of Central Asia, China, India, Morocco, the Pacific Isles, etc., have no other process of rendering harmless the dangerous waters of their marshes and rivers. In a time of epidemic it is always prudent to have recourse to the boiling of water. If boiled in the evening, for three or four minutes, the water is cleared and sufficiently aerated the next day ; it may be drunk without danger. To increase the precaution one might add before boiling some drops of permanganate of potash or lime until it becomes persistently pink coloured, which colour would disappear by boiling in a moment. By means of these precautions, the most dangerous waters can be drunk without any disadvantage accruing.[1]

[1] Some filters have been made where the water flows slowly after having been brought to boiling point and cooled (See *Presse médicale*, March 5, 1904).

XXXIII

RATIONAL PREPARATION OF FOOD—DISTRIBUTION AND COMPOSITION OF MEALS—AIDS TO DIGESTION

AFTER having established what is the normal allowance for a man in health, in repose or at work, and studied the different foods of animal, vegetable or mineral origin which turns to account, it remains for me, before passing to the examination of alimentary diets, in each of the stages of health or sickness, to say some words on the rational preparation of foods and on the best composition and distribution of meals.

Preparation: Presentation of Food.—The manner in which foods are prepared and presented may influence their use and digestibility still more than it influences their actual composition. The stomach has its perception on which the senses of sight, smell and taste react and is subject to psychical impressions, emotions and recollections, as Pavlow has established scientifically. He has shown that the sight of pleasing dishes (such as meat, for example, in the case of dogs) like their odour, produces before they have had any direct contact with the mucous membrane of the mouth or the stomach, a specific salivary and gastric flow which prepares and provokes digestion and definitive pepsic secretion. It is necessary then that the appearance, odour, savour and variety of the foods should first please our senses and satisfy even our mind in order to prepare the stomach to digest them well.

We should be wrong not to take count of these important factors. The pleasure and repugnance which such or such a method of presenting and seasoning a food inspires, spurs the digestion, so to speak, excites or hinders the stomachic functions, and if this is true in the case of a man in good health, it is still more so in the case of one weak or ill.

A food which pleases will be generally well digested ; if it is repugnant it is already more than half useless ; often even indigestible and consequently dangerous.

Cooking.—The cooking of food is an immemorial practice. Since man has known how to make fire, he has cooked certain dishes either when it was a question of meats to develop their aroma and flavour, or in the preparation of vegetables to make

them digestible. But cooking has another and more important rôle still. It acts as an antiseptic to the foods by destroying all that, while living, might become dangerous.

From the point of view of chemical transformations, cooking does not modify fatty bodies and the sugars only very slightly. On the contrary, it hydrates, swells and brings about the bursting of the grains of starch which it transforms into amylodextrins, dextrins and assimilable sugars. It softens and disaggregates the tough parts, destroys the envelopes of many of the vegetable cells, and by increasing the surfaces assures insalivation, more complete grinding by the teeth and the stomachic or intestinal solution by the digestive ferments.

The granivorous animal which digests grain is obliged to subject it to the mechanical action of his energetic muscular stomach ; it is sufficient for man to cook these same foods or their derivatives, to attain the same result with a much less powerful stomach.

Albuminoid matters are modified, more or less profoundly, by boiling with water or roasting. Heat coagulates the albuminoids, gelatinizes the cellular membranes or softens them. The roasting of meat raises it slowly in the centre to 70° to 85°. Liebig considered that it was cooked when it had throughout reached the temperature of 60° only.

It has been said, à propos of muscular tissue, that cooking makes it more digestible and more accessible to mastication, but it also removes its natural ferments. By way of compensation, it destroys (at least in boiled meat) the morbid germs, the typical ferments, and nearly all the parasites that it may contain in the fresh state. For vigorous stomachs, raw or much underdone meats are not as good then as well roasted or boiled meats.

The minute modifications which roasting causes meats to undergo, influence at once their composition, their taste and their digestibility or use (see p. 41). They should not all be subject equally to the action of heat. An old saying that I heard quoted many times at table in my youth used to run, and, I believe, with reason : *Very young lamb ; underdone mutton ; roast veal ; thoroughly cooked pork.* Nothing is more unpleasant and sometimes more dangerous by reason of their parasites or febrile ferments than certain beefs or porks which are underdone.

Temperature of the Foods.—As a rule foods ought to be taken warm and drinks cool. But drinks need not be icy or foods burning. Too much cold or heat causes the cracking of the enamel of the teeth, which slowly decay. Drinks which are too cold end by weakening the stomach by the constant stimulation they give. They may besides disagree and many visceral rheumatisms, which are not due to any other cause, disappear

when tepid or warm drinks are substituted for icy or even cold drinks.

As for solid foods consumed cold, they only agree with vigorous stomachs. Again warm meals are always better than cold.

Foods taken at too high a temperature are not to be recommended in any case. Kostjurin and afterwards F. Spoeth made some experiments on this subject on animals and man, from which it follows that all foods reaching the stomach at a temperature higher than 50°, occasion uneasiness, hyperæmia of the mucous membranes, hinder the production of the digestive juices and compromise the efficacy of their ferments. The stomachs of rabbits and dogs which have received by the œsophageal tube the water at 60°, even when it is followed immediately by a dose of cold water, are inflamed, infiltrated and sometimes ulcerated in places.[1]

The most appropriate temperatures for taking different foods are the following :—

Drinking water . . .	9°–12°	Soups	40°–50°
White wines, beer . .	8°–10°	Purees	40°–43°
Red wines	16°–18°	Roasted meats . . .	40°–45°
Coffee, chocolate . . .	45°–50°		

It is advisable that one dish, at least, per meal be taken warm, and soup for preference. An entirely cold meal is a condition unfavourable for the liquefaction of the gelatines, fats, etc., or for bringing about their emulsioning and good digestion. Cold meals should at all events be accompanied by a warm beverage, such as tea or coffee, and in case of need, by some cubic centimetres of brandy to excite the gastric secretion sufficiently. It is thus that the instinctive necessity of rewarming a stomach which only receives cold foods leads, or may lead, the workman and peasant, who is often obliged to eat cold things, to the abuse of alcoholic drinks.

Condiments.—Condiments and sauces, etc., modify the taste of foods and are used to make them more agreeable, appetizing and stimulating. These skilful and sometimes delicate accessories are less agreeable to healthy and vigorous stomachs. They often correspond rather to the satisfaction of a pleasure, more or less artificial, than to a real want.

Fatty sauces as a rule hinder digestion and only agree with strong stomachs. Spices hasten digestion but irritate the digestive tubes. All these preparations give to blunted or weak appetites a satisfaction—a little artificial it is true—but also sometimes a help. Some invalids may be allowed to employ them, but they do not agree with fever patients, gastral-

[1] St. Kostjurin, *Petersburger medizinische Wochen*, 1879. F. Spoeth, *Arch. f. Hygiene*, 1886, p. 68.

gics or hyperchlorics. Dishes too highly seasoned, too much spiced, may by degrees lead even healthy stomachs to an excessive consumption and all its consequences.

Culinary Vessels.—The vessels in which we cook or serve up our foods ought to be suitably chosen. Earthen vessels covered with an impermeable vitrefied glaze and earthenware should only be employed for cooking vegetables if their glaze does not contain or yield any lead, even with vinegar and salt water, which is boiled in them for some time. Water and foods, especially acid foods, may in fact borrow this dangerous metal from the glazing of coarse earthenware when it contains lead and has been imperfectly baked in the fire. Several cases of lead poisoning have been produced under these conditions, especially in our colonies.

Vessels of glass and ordinary porcelain are very healthy. They have not the disadvantage of cracking like pottery, which, in becoming thus slightly permeable, always collects and keeps in its flaw, in spite of repeated washings, traces of previous meals. Becoming putrid, they communicate to these utensils, a special odour and may even sometimes become a cause of change in the dishes that one serves or keeps in earthenware.

Cast-iron vessels give an inky taste to some foods. The iron should therefore be enamelled. An unchangeable enamel is made at the present time from an aluminous-alkaline-earthy silicate ; it is free from lead and stands fire well. Unfortunately many of these enamelled saucepans split, crack and may introduce little pieces of their glazing into the food. Good modern enamels are free from lead and have not this disadvantage. It appears to me a mistake to attribute to this cause cases of appendicitis which have become so numerous to-day.

Vessels of red copper not tinned do not give rise to any appreciable danger, as M. Galippe has well established, but they communicate to foods a very disagreeable metallic taste which, moreover, suffices to warn one of the presence of this metal and prevent any serious accident. In reality, very bright copper vessels, well cleaned, may be said to present no danger. Those which are lined with pure tin (999 thousandths at the least of tin with 0·5 per cent. of lead at the most) and *à fortiori* silver utensils are excellent for cooking. The same holds good for pure nickel (A. Riche, Geerkens) and for vessels of aluminium, a metal indeed little suitable for use and very liable to be changed by culinary agents. The numerous alloys called white metal, Algiers metal, German silver, packfong, Britannia metal, Queen's metal, etc., alloys into the composition of which copper, lead, antimony, zinc, tin, and even arsenic, enter, are only suitable for other purposes.

Tin vessels should be of pure tin. At most, and for reasons

of economy, certain hospital administrations and managements allow it to contain 5 per cent. of lead or other impurities. Unfortunately many tin goblets, plates, etc., in our hospitals, and many old vessels of tin, contain 10 per cent. and more of lead. I have already proved elsewhere that with 10 per cent. and upwards of this last impurity, a tin vessel is slightly attacked by pure water, sweetened water or acidulous water, which dissolve a part of the toxic metal.

Distribution of Meals.

Like the ancient Greeks, our forefathers took three meals; two light ones, one in the morning on getting up, the other in the evening when the day was done and the sun set, and a principal meal, that at midday, usually followed by a siesta with one or two hours rest. The needs of modern activity have caused the copious midday repast to be replaced by a lighter meal which allows, without the siesta, intellectual or physical work almost immediately afterwards, but which necessitates a second substantial meal in the evening, six or seven hours after that of midday, generally three hours before the night's rest. To these two principal repasts, of fairly modern origin, are usually added, in France and Germany, the light déjeuner which follows rising and sometimes, at least in the case of children, the light meal, about four to five o'clock (five o'clock tea in England, the Vesperbrod of the Germans). This division of meals, without being absolutely hygienic, appears fairly suitable. In England, in families in easy circumstances, and in many houses in Germany, breakfast is taken at nine o'clock, dinner at two (this is the principal meal), and tea at five with a little tea, coffee, cocoa, beer, butter, bread or ham, and lastly a light supper before going to bed.

Fifty years ago in France, the meals were more logically distributed; rising in the morning about six o'clock followed by a very light meal, dinner about eleven (not heavy), the principal meal, supper, being about six o'clock. One had thus from seven to eleven o'clock in the morning, from one to six o'clock in the afternoon, nine hours free for work; a further three hours from seven to ten in the evening for pleasure, walking and family gatherings, with eight hours for sleep. Under these conditions the supper at six o'clock came just at the moment when the losses in substance corresponding to the daily bodily work had need of being made good. It was taken rather early in order that the stomachic digestion of this evening meal should be very nearly finished at the time of going to sleep. That of the midday meal was far advanced when one went back to business one or two hours afterwards.

The nature of the meals should vary with the nature of

the occupations. A sufficient but light déjeuner about midday suits those who are occupied chiefly with office work or business. But for the workman or peasant, who, from six to seven o'clock in the morning to midday or one o'clock has already taken tiring exercise, the midday repast should be sufficiently liberal and allow him not only to make good his losses, but also to provide him afresh with disposable energy.

What is not proper is to take all the nourishment for twenty-four hours at one time. The stomach digests it less easily; under these conditions it remains surcharged for some hours, and the needs in actual or reserve energy are not so well satisfied.

It is necessary in digestion that each transformation should take place at its proper time. Pavlow has shown that after meat has been introduced into the stomach, several minutes elapse before the pepsin is secreted. This is without doubt the time that the ptyalin employs to transform the cooked starch into sugar. Later the acidity of the gastric juice produced must be sufficient to secure that on arriving in the duodenum it excites the pancreatic and intestinal secretion. An insufficient mastication, a hurried meal, upset this combination of acts which harmonize and complete one another under normal conditions; digestion becomes laborious and abnormal in the contrary case.

We must then eat without hurry, giving ourselves time to masticate and insalivate. Incomplete mastication causes lingering and imperfect digestion; it may give rise to intestinal catarrh.

However, meat badly masticated is more easily digested than the bread or vegetables which accompany it and which are too rapidly swallowed. Fr. Strümpell, after a dish of boiled lentils swallowed whole without being chewed, found 40 per cent. of the nitrogen taken in under these conditions, in the fæces. The same thing practically applies to other vegetables or to bread too new and badly insalivated.

Finally, one must not during meals give oneself up to intellectual work, reading, calculations or preoccupations of any sort. Meals taken alone are on this account unfavourable.

Composition of Meals.

Alimentation becomes more and more animal and richer in fat bodies as we get nearer to the Poles. The population on the borders of the Frozen Sea, the Laplanders, Greenlanders and Ostiaks feed almost entirely on fish and the flesh and fat of seals, as much from instinct as from the impossibility of doing otherwise. The Arab, on the contrary, is satisfied with some dates and a little couscous, the Neapolitan finds his macaroni

sufficient, while the people of the intermediate zone mix in a rational proportion their nitrogenous, fatty, sugared and starchy foods.

In France the amount of meat per head is, as we have seen, 39 kgs. per annum. We have said (p. 125) that it rises to 59 kgs. in England and 94 kgs. in Paris. It is 72 kgs. on an average in the big French towns and only 19 kgs. in the country. The peasant then has scarcely 26 grms. of fresh meat per meal. We see that this quantity is insufficient for the workman and labourer who have most need of it. Even at the present time meat is only, so to speak, a relish for the countryman. A man living in a town, on the other hand, generally eats more meat than agrees with him. We have seen that in Paris the alimentary principles of animal origin exceed 480 grms. per day, 260 grms. of which are meat, and this figure must be at least doubled for many unoccupied townsmen.

Like the opium smoker, the individual who accustoms himself to meat, feels that he misses it when he does not take the usual excess. It is the illusion of the morphia-maniac, the tobacco-maniac, of the alcoholic, etc., the harmful exaggeration of the man in easy circumstances who believes that he is satisfying a need only created by himself, who takes his pleasure in making himself ill, and who thus often imagines he is defending the interests of his health.

Supposing that he takes two or three dishes at each of his two or more principal meals, the average man who does not do manual work ought not to eat more than 250 to 300 grms. of meat or fish per day[1]—a woman a sixth less. For the other food it is enough if he does not depart perceptibly from the allowance that we have established by experiment and theory (see Part I., p. 24)

In contrast with the man in easy circumstances, the peasant is short of meat, as we have just observed. His alimentation is too exclusively vegetable and forces on him a perpetual digestion of dishes of great size which nourish him badly: potatoes, green vegetables, fruits, etc., which bring him only an insufficient quantity of nitrogen. Hence the gastralgia, dyspepsia and enteritis so frequent in this class. This imperfect diet is happily counterbalanced by work in the open air, ventilated, isolated and sunny dwellings, good rest at night and sometimes in the middle of the day, and the minimum of incitements to intemperance or vice. But nevertheless, owing to his defective alimentation and in spite of so many other advantages, the average life of the countryman is still shorter than that of a man of the middle class and the workman in towns.

[1] Each egg may be reckoned at 40 grms. of meat.

The workman in towns lodges, too, under insanitary conditions; he lacks open air and light, he often does work out of proportion to his alimentation. He sometimes sacrifices for his pleasures the time for sleep.

The handicraftsman should consume per day at least 500 grms. of meat, 700 grms. of bread and 80 to 100 grms. of fatty bodies. A diet composed of 300 grms. of meat, 250 cc. of milk, 100 grms. of dry vegetables, 70 to 80 grms. of ham or bacon, 200 grms. of potatoes with all the variations which present themselves in practice agrees with him perfectly, especially if he can add to it a little wine (250 to 500 cc. per day) and a cup of coffee.

Whatever be the social position of the family or individual, what is to be especially avoided is exclusive alimentation. There are some tables from which vegetables are almost excluded *because* it is said that *they are not sufficiently nourishing*, or because they do not make a good enough show, or because they do not please palates accustomed to the incisive taste of meats, sometimes because their preparation demands more care and time than the housewife can give to them—for example, in families in which she goes out to work. It is thought possible by an excess of nitrogenous alimentation to make up for the deficiency, intentional or not, of vegetables. That is a very dangerous error. With such a dietary, children grow up nervous, cacochymic and eczematous; later on they will be arthritic, gouty, calculous, megrimous and neuropathic. *I have no doubt that the degeneracy that has been noticed in many well-to-do families is due particularly to an alimentation composed too exclusively of flesh which they have gradually adopted.* For a stronger reason we ought not to further exaggerate this tendency by replacing beef and mutton, roast or boiled, by pork-butcher's meat, hash, game, preserved fish, spiced stews, salted or smoked meats, by that of animals too young and by fermented cheeses with the necessary accompaniment of bitters, stimulants, spices, wines, liqueurs, coffee, tea, etc. . . . Such an alimentation entails every sort of disorder of the health, makes the race degenerate and decimates families.

Bread, Meats, Fresh or Dry Vegetables.—That is the solid and rational basis of our meal, and if, in some cases, there is occasion, for reasons of hygiene or economy, to give preference to one of these categories of foods, it is towards vegetables that it would be wise to incline without excluding meat, or at least fish, from the principal meal.

There is a period of life in which nitrogenous foods are more particularly indicated and, as it were, instinctively sought after. It is when puberty is being established. In the case of the young girl from fourteen to sixteen years of age and the boy of

sixteen to nineteen years, an alimentation particularly rich in meat is as necessary as plenty of sleep, and often more food by weight, than in the case even of the adult, is necessary for these young people. It is not, unfortunately, the rule generally followed in our boarding schools and *lycées*, where everything continues to be done, not from the point of view of science and reason, but from that of administration, that is to say with parsimony and by routine.

Beyond the age of adolescence, we think that it is not wise, when in good health, especially for those who do not take fatiguing exercise, to allow oneself to satisfy one's appetite completely at each meal.

We have already said that the good preparation and agreeable presentation of the meal has a great influence upon the digestion. A clean and well laid table cheers the spirit and at once satisfies the stomach. The good smell of the dishes, their sapidity and warmth from the moment that they reach the mouth, excite the secretions of the digestive juices. Cold or warm drinks, by reason of the stomachic contractions which they provoke, rapidly carry towards the intestines the parts already more soluble. The stimulation of the muscular tissue starts in a still more active manner the hepatic and intestinal secretions. Variety in the dishes, by provoking different sensations, prevents the appetite from becoming used to a food, and preserves its keenness.

For many reasons, which we have already developed, meals ought to be made up in such a manner that they bring us a total of sufficient alimentary principles in a moderate volume and weight.

The meal of the Parisian weighs, drinks deducted, about 550 grms. It scarcely reaches 1 kg. with drinks. The weight of the workman's or peasant's meal, especially in poor countries, drinks not included, rises to 1,000 and 1,500 grms. without furnishing him with a sufficient quantity of nutritive principles.

When eating, one ought to drink according to one's thirst, and not be stopped by the consideration that, in the case of hydrochlorics in particular, water diminishes still further the too low standard of acidity of the gastric juice. Warm or cold drinks taken in moderation provoke and increase rather than diminish this secretion. Besides, according to Von Mering and Moritz, drinks pass very rapidly through the stomach, the contractions of this organ pushing them rapidly, by successive jets, into the small intestine. 500 cc. of water pass thus in the case of a man through the pylorus at the end of half an hour, when, the stay of meats in the stomach in the presence of the gastric juice, the secretion of which continues, usually exceeds three hours.

The use of water, and I add beer and milk, during the meal can only be harmful when excessive; but in the case of milk or beer, their nutritive principles should be taken into account. These are not simple aqueous drinks.

Drinking water by charging itself with dissolved particles, makes their absorption more rapid and allows what remains in the stomach to be more easily digested.

Aids to Digestion and Appetite.

I shall confine myself to pointing them out here in a few words only.

To help or accelerate digestion, we may have recourse to physical means, to chemical or alimentary aperients and to medicinal agents.

Amongst physical stimulants, exercise and mechanical work, walking and movement in fresh air, residence in the mountains or by the sea, gymnastics, hydrotherapy and massage should be cited.

Every one knows the influence which muscular fatigue exercises on the appetite and digestion when it is not excessive, as also bodily exercises, games and walking in fresh air, gymnastics and sports of every kind. A simple holiday in the mountains or by the sea, living in the country, suffice to revive and give tone to the stomach. For invalids and convalescents, drives in an open carriage act in the same way and perceptibly favour digestion by the movement they give to the contents of the stomach.

Sea baths in particular, and even merely a visit to the seaside, powerfully excite the assimilatory functions.

On the other hand, the appetite quickly becomes small in the case of a child, convalescent or invalid, deprived of pure and fresh air, living inactive in a confined locality in the middle of large towns.

As to the question whether we should or should not take exercise immediately after meals, we shall reply that the solution of this problem depends on the state of health of the subjects. Young people in full vigour have no need of rest to digest their food; on the other hand old people, gastralgics, hydrochlorics, chlorotics, neurasthenics, etc., those who have a troublesome or weakened stomachic or intestinal digestion, those who suffer from giddiness, insomnia, headache, muscular weakness, palpitations, etc., all these should be allowed, while their digestion is going on, some rest, an hour at least, after the meal.

All intellectual work at all intense should be avoided immediately after eating.

Moderate massage, especially abdominal massage, may, up to a certain point, take the place of exercise, hasten the digestion and particularly cause constipation to disappear. Hydrotherapy and cold baths act in the same way.

Condiments are, as we have already said (p. 264), the alimentary stimulants of the stomachic and digestive function. But they should be used with prudence, particularly spiced or bitter condiments, because the stimulus they give, becoming slowly deadened, we are led to increase day by day the use of these dangerous agents. Gastritis and enteritis, or simply disappearance of the appetite, are the grievous consequences of this abuse,

Amongst the more harmless alimentary digestives we can cite : wine taken in small quantities, fermented cheese, sugar, and in some cases coffee, tea and different aromatic dishes, such as seasonings, sauces or ingredients of which we have already spoken at some length.

Finally, amongst the aperients that we can call medicinal we will mention the bitter beverages : hop, quinquina, rhubarb, bitter orange peel, gentian, alder, tansy, quassia, strychnia, etc., in maceration with water, sometimes in liqueurs which lessen their bitterness.

These excitants should only be used in very small quantities and at meal times.

The liquids called aperients are often aromatized with cinnamon, coriander, aniseed, cloves, nutmeg and vanilla which are also stimulants of the stomach. It is wiser to do entirely without these stimulating drinks when one can, or, at any rate, only to make exceptional and very sparing use of them.

PART III

Regimens

XXXIV

ALIMENTARY REGIMENS—THEIR INFLUENCES ON RACES, APTITUDES, MENTAL WORK—VARIATIONS NECESSITATED BY CLIMATE AND SEASONS

THE *alimentary regimens* are the modes of alimentation which more especially aim at satisfying certain needs of the individual, the object of which, in the case of pathological troubles is, while nourishing the invalid, to help to restore him to health.

Whether, in the case of animals or man the object be, by means of special alimentation, to cause such or such aptitudes to prevail—for example, muscular force, resistance to extreme climates, force of character, cerebral activity, etc., or whether one is trying to satisfy in the best way possible the needs created by the rapid development of the young being, and later by the coming of puberty, by pregnancy and by suckling; or whether efforts are being made to modify by alimentation the temperament of an individual or his mode of discharging functions, to renew the strength of the convalescent, to support the invalid according to the indications furnished by his constitution or present state in such a way as to restore him to health as quickly as possible, etc.; in all these cases it is advisable to regulate alimentation by a special regimen; and the rules and practice which originate from this fact deserve to be carefully stated and discussed from the physiological, chemical and clinical point of view.

Understood in its broadest sense *regimen* would include all that relates to foods, beverages, exercises of the mind and body, to sleep and to waking, to clothes, etc.; in a word to all that tends to protect or serve the individual and to favourably modify this condition. But we shall limit ourselves in this special work to the study of *alimentary regimen.*

Strict Regimen and Regimen "de luxe"; Their Influence on the Constitution and Health.—We have already established in Part I, basing ourselves both on national empiricism and on observation of the physiological needs and the losses of the system, what are, in quantities and kind, foods best suited to the healthy adult, either inactive or at work. The alimentary allowance in our climate gives an ordinary average man per day 107 grms. of albuminoids, 65 grms. of fatty bodies and about 400 grms. of starchy or saccharine matters including those which have a potential value equal to that of alcoholic beverages. But we have established on the other hand that the quantity of albuminoid substances can be reduced strictly speaking to 80 grms. per day in the case of the man who does not work, on condition that his foods supply him at the same time with at least 50 grms. of fats and 485 grms. of carbo-hydrates destined to provide for the requirements of calorification, which varies greatly according to the temperature of the surrounding atmosphere. For the French workman who does eight to ten hours work, the daily ration should contain at least 135 grms. of albuminoids with 58 to 100 grms. of fatty matters and 500 to 900 grms. of starchy matters according to the amount of fatiguing or excessive effort exacted from him.

These different allowances may be realized with the most varied foods provided that they are sufficiently digestible and assimilable, and that the weight of the alcohol substituted for sugar and starchy substances does not exceed 1·2 grms. to 1·5 grms. per kilogramme per day of the weight of the body of the subject.

If then in our climate, and for the man in relative repose, 80 to 82 grms. of albuminoids (about half of which are furnished by muscular tissue and half by other foods) are strictly speaking sufficient, and if into the daily alimentation, as happens in Paris, for example, there enter 102 grms.—the difference, that is to say, 20 to 22 grms., corresponds to a regimen of storage or "de luxe."

The same may be said of the other principles which enter into the ordinary allowance of food.

What are, from the point of view of health, the significance and the result of this, at least apparent, excess of proteid or starchy principles in our daily regimen?

Like the small workman without capital, who lives from day to day, the man who receives only just the necessary amount of food is constantly in danger of a deficiency. Whether the work imposed upon the animal machinery happens to be irregularly increased; whether the functions and particularly the assimilatory functions be slightly disturbed; whether owing to a fall in the surrounding temperature, the radiation of the body increases; or whether sleep brings about insufficient repair, etc.,

each of these causes, and many others besides, by diminishing the receipts or increasing the expenditure, will augment the deficiency, and if there are no reserves, it will be by the combustion of the substance of the organs that henceforth a part of the mechanical work or even the maintenance of the animal temperature will be effected. Our fats exhausted, we shall then destroy, at least in an intermittent way, the proteids of our tissues in place of the sugars and of the defaulting fats. In order to avoid these deficiencies and losses, in order not to be driven to warm the house by burning the utensils, the system must then have a reserve at its disposal, namely, that created by a regimen called " de luxe." At least it is necessary that the gain of to-day should suffice to compensate for the loss of to-morrow, and that by means of a sufficient alimentation, it should be possible for a sort of mobile equilibrium to be established, in which the losses will never exceed the supplies, especially in albuminoids and mineral salts.

It is then very important that we should have a slight excess of these fundamental alimentary principles every day. But this excess in its turn becomes dangerous if it goes beyond certain limits. The alimentary fatty bodies, the albuminoids of muscular tissue for example, if they are not utilized and burnt up by means of mechanical labour, by the powerful working of the lungs and skin, a sufficient combustion and a proportional radiation of heat, will, with all their wastes, accumulate in the organism, producing there obesity, visceral congestions, neuropathic conditions, arthritis, diseases of the skin, etc. What would be an excellent regimen for the workman and the labourer working in the open air, will then become a deplorable alimentation for the sedentary citizen who takes but little exercise, or for the artist and the scholar who give themselves up to intellectual work only. In the case of young people, and those whose organs, whatever be their age, have nearly preserved their normal activity, a slight excess of alimentation will have no other effect than necessitating a greater activity of the lungs, muscles, skin or kidneys. But this will not apply to the man who is growing old, or whose constitution or bodily habits are defective to begin with. In such a case an excess of alimentation will daily accentuate decay ; hepatic or pulmonary congestions, arterio-sclerosis, alteration of the kidneys, fatty degeneration of the various organs, etc., will go on increasing, thus will become established little by little, if not disease, at any rate a predisposition to it, a diathesic state and morbid bodily habit. If then, it is advisable to eat sufficiently, alimentation should be proportional to our needs and regulated not only by our natural appetite but by our reason, aided, when necessary, by observation and science and not accommodated to bad habits or artificial stimuli.

Influence of Regimens on the Characters of Individuals and Races.—If alimentation acts on the general health by reason of its scantiness or excess, it acts on us still more perhaps by its nature. It is universally notorious that the most active, the most robust, and the most aggressive people are great meat-eaters. I shall only quote the English and the Germans. Granivorous and frugivorous nations are nearly always peaceful, such as the greater part of the nations of Central Asia, for whom rice and vegetables, with a little pork or fish, form almost solely the whole food. One cannot help coupling with these facts the remark that carnivorous animals are generally fierce and dangerous, whilst the herbivora, on the contrary, are easy to live with and to domesticate. More or less exclusive carnivorous alimentation is, to a greater extent even than race, one of the factors of the gentle or violent character of an individual. It is known that the white rats of our laboratories, as long as they are fed on bread or grain, are very manageable and easy to tame, whilst they become snappy and given to biting from the time they are fed on flesh. The same observations have been made in the case of a horse and even of a dog, although the latter is omnivorous. Liebig relates that a bear kept at the museum at Giessen was gentle and quiet when it was fed exclusively on bread and vegetables, but a few days of animal diet caused it to become fierce and dangerous to its keeper. They used to amuse themselves by thus periodically altering the animal's character. It is known, adds Liebig, that the irascibility of pigs may be increased by a meat diet to such an extent as to cause them to attack men (*Nouvelles lettres sur la chimie ;* 35th Letter).

A carnivorous regimen then certainly influences personality ; it makes us more aggressive, harder, more self-willed. I am not speaking of its bad influence on the general health, which I shall treat of later on à propos of exclusive regimens, my only object here being to show its special action on the moral qualities.

Reciprocally, it is certain that a diet too exclusively vegetable weakens the violence of temperaments and softens manners. This has been well understood by all founders of religious orders both in Europe and in India, who limited or prohibited foods of animal origin. We have seen that vegetable food is less completely assimilated ; it imposes on the animal a far more powerful intestinal work which diverts part of its disposable energy to the accomplishment of these lower functions, it introduces into the system, far less than meats, those bitter bases, those sapid extractive matters which are stimuli of the heart, the circulation in muscle and mechanical energy. It is then manifest that an alimentation too exclusively vegetable perceptibly weakens and softens the will. Food is perhaps sufficient to transform the

wolf and wild cat, some of the most dangerous carnivorous animals, into the domestic dog and cat.

If diet acts thus on the development of the organs and character, it is impossible to deny that it also modifies races. Lamarck and Darwin were of opinion that alimentation which creates internal conditions was, with the influence exercised by external conditions, and selection, the preponderant cause of the variations observed in animals and plants. Without sharing this opinion, for reasons I have stated at length elsewhere (*Revue générale des sciences*, Dec. 15, 1901, p. 1,046), I believe however, that the qualities peculiar to each individual and each race are perceptibly influenced by the continuous action of alimentary regimens, and reciprocally when habits are contracted and temperaments created by a long heredity, special regimens often become necessary to races thus modified. An Englishman or Dutchman becomes weakened by being deprived of meat far more quickly than a Spaniard, Southern Frenchman or Italian, and these latter when fed on the same food, if it is almost exclusively vegetable, will do much more work than a member of the northern races.

Influence of Diet on Mental Effort and of the Latter on the Digestive Functions.—The influence of diet on the physical vigour and character of races brings with it, as a consequence, its action on intellectual aptitudes. We have learned that man in order to do mechanical work, has need not only of an alimentation abundant in ternary principles, but especially rich in meat. This regimen, which develops muscular force, energy, vigour, even violence is, on the contrary, not very favourable to the culture of artistic or scientific aptitudes. To those who give themselves up to the speculations of thought, who require to exercise their power of observation or generalization, to develop or express their artistic sentiments, to cultivate abstract sciences, etc., bread, green vegetables, ripe fruit, a little wine, and for nitrogenous food 150 to 200 grms. of meat, fish and poultry per day, eggs, milk and other foods easily digested (rice, carrots, cauliflower, asparagus, mushrooms, a small quantity of potatoes, etc.) and finally a few aromatic condiments such as coffee, tea, etc., are more suitable than diets too essentially carnivorous. And the more so because those who devote themselves to works of the mind or imagination, generally take insufficient physical exercise, thus constituting themselves candidates for arthritis, gout, hepatic, cerebral and renal congestions. Such predispositions are often again increased in their case by the abuse of coffee or tea, sometimes of alcohol or tobacco, and the desire for condiments which momentarily excite the appetite which sedentary work tends to weaken. For them the dishes to avoid are those which are difficult to digest or which require to be taken

in a great quantity, too abundant meats, too starchy vegetables (dry beans, lentils, broad beans, etc.).

In the case of all those in whom sentiments, artistic impressions, researches of the imagination, the speculations of ambition or public affairs predominate, the alimentary allowance should be that which corresponds to their feeble corporeal activity and to the climate in which they live, as psychic manifestations, we have seen, do not correspond to any sensible loss. Beyond all doubt, all brain work consumes energy corresponding to the effort made to put the sensorial machine in a fit state to receive an impression, transform it into a physical shape, and finally present it to the inner sense. All brain work causes then a real loss of energy felt and known by all those who know how to observe themselves. Every impression, besides, as Moritz Schiff has directly demonstrated, heats the brain and the organism and causes, as a consequence, an expenditure of energy. But this expenditure is so small that it is imperceptible from the alimentary point of view. In fact it has been recognized that intellectual fatigue does not increase either the quantity of the total urinary nitrogen and consequently the quantum of albuminoids broken up or the combustion of fats,[1] or even the weight of the phosphorus excreted in a given time.

A last remark : Intellectual work should never be undertaken during a meal nor at the beginning of digestion, when the organism requires that the blood should flow not to the brain, but to the stomach.[2]

Variations of Diet with Mechanical Work.—This important question has been already discussed at length in Part I of this work with reference to the variations of the food allowance in the case of a man doing nothing and at work (p. 88 seq). The next chapter will also give information concerning the variations of diet for workmen in different climates.

Variations of Alimentation according to the Height and Weight of the Body.—In order to render proportional the alimentary allowance to the height and weight of the body, it will be necessary to remember that in Part I of this book it was established (p. 98), that *in a state of repose or simple maintenance,* about 72 hundredths of the virtual energy stored up with foods, are scattered at the surface of the body under the form of heat radiated or lost by con-

[1] Speck, *Arch. f. exp. Pathol. u. Pharm.*, Bd. XV, p. 81; C. Voit, *Zeitsch. f. Biolog.*, Bd. XIV, p. 57.

[2] During *sleep*, the destruction of the nitrogenous principles of our tissues does not appear to vary ; but that of the fatty bodies becomes greatly enfeebled without the amount of oxygen absorbed always diminishing in proportion. There is often an accumulation of oxygen in the system during the night's rest, especially in the case of young children (Made. Brès ; Ch. Bouchard).

duction, and 28 hundredths are transformed into different work or thrown off in the form of latent heat of vaporization with the water expired or perspired. Now this last part of the energy lost is proportional to the weight W of the individual functioning, the heat lost by radiation is (all other things remaining equal) proportional to the surface of the body S.

Supposing ourselves placed in normal conditions of health, let us represent by m the heat lost per unit of the surface of the body S expressed in square decimetres, and by n the heat lost at the same time (or energy expended) per unit of weight W expressed in kilogrammes, we shall have, representing by C the quantity of heat corresponding to the total energy expended, during a period of twenty-four hours for example :—

$$(a) \quad mS + nW = C.$$

We know also that, between the energy mS radiated by the surface and that nW lost under the form of work, heat of vaporization, etc., the following experimental relation exists :—

$$(b) \quad \frac{mS}{nW} = \frac{72}{28}.$$

On the other hand, for normal or average cases, it is possible for us to know the habitual relation between the weight of the body and its surface. Professor Bordier has, at my request, kindly studied this relation, and the following are the results which he has obtained with adults by his *intégrature de surface*[1] :—

[1] M. Ch. Bouchard (*C. Rend. Acad. Sciences.* t. CIV, p. 844) gives for the *normal man* the following formula which endeavours to connect the weight of the body W, expressed in kilogrammes with the surface S, expressed in square decimetres, with the height T and the circumference C.

For man : $S = 0,48\,CH + 8,33\,\frac{W}{C} + 3,47\,H\sqrt{\frac{P}{3,14\,H}}$

For woman : $S = 0,48\,CH + 6,44\,\frac{W}{C} + 3,03\,H\sqrt{\frac{P}{3,14\,H}}$

This formula applies particularly to subjects of normal corpulence. $\frac{W}{H} = 4{\cdot}2$ for man and $\frac{W}{H} = 3{\cdot}9$ for woman.

Meeh's formula which connects the surface S with the weight W of the individual is $S = K\sqrt{W\frac{2}{3}}$; this formula is inexact, the surface varying very perceptibly with the size in the human species. The coefficient K is about 4·1.

Relations observed between the Size, Weight and Surface of the Human Body by Prof. Bordier.

Height.	Total Surface S in sq. decimetres.	Average of Results.	Weight W.	Average of Weights.	Relation $\frac{W}{S}$
m.	sq. dm.		kgs.	kgs.	
1·79	194·45	—	73·500	73·500	0·377
1·75 [1]	194·20	193·8	80	75	0·386
1·74	193·40		70		
1·70	188·14	180·3	69	67·1	0·366
1·70	180·72		66·500		
1·70	172·92		65·700		
1·66	169·67	168·4	70	65	0·386
1·65	167·10		60		
1·60 [1]	168·14	171	60·800	61·1	0·357
1·60 [2]	175·00		61·500		
1·60 [2]	171·00		61		
1·55 [1]	159·92	161·2	53·300	55·5	0·350
1·55 [1]	162·46		57·800		
				General average	0·370

We see that if the surface S is expressed in square decimetres and the weight W in kilogrammes, the above figures give the average value :—

$$(c) \quad \frac{W}{S} = 0{\cdot}37$$

(with some slight variations between 0·35 and 0·38).

Having learnt (p. 61) that in the state of normal maintenance the energy C is equal to about 2,400 Calories, we shall obtain from the three equations (*a*), (*b*) and (*c*) :—

$$n = 10{\cdot}1 \text{ Cals.}$$
$$m = 9{\cdot}586 \text{ Cals.}$$

Thus the average energy n, expressed in Calories, *lost by man in a state of maintenance in the form of mechanical work or of latent heat of Vaporization of water per kilogramme of body weight, is* 10·1 Calories, *and that which is lost at the same time by radiation or conduction and per square decimetre of surface m, is equal to* 9·59 *Calories.*

Knowing these coefficients, if we refer to the table of averages resulting from the measurements of M. Bordier, it will be quite easy to find the number of Calories x necessary to the maintenance of a man of weight W. For 75 kgs., for example, we shall have according to the equation (*a*) :—

$9{\cdot}59$ Cals. $\times 193{\cdot}8 + 10{\cdot}1 \times 75 = x$; whence $x = 2{,}615$ Calories.

For the weight W = 65 kgs., we shall find :—

$$x = 2{,}271.$$

[1] For two different subjects. [2] For three different subjects.

According to the number given (p. 98) for the working adult, we should calculate in the same way the value of m and n in the case in which the adult gave himself up to mechanical work, knowing that in this second case 60·3 per cent. of the energy is lost by radiation, and consequently increases proportionally to the surface, and 39·7 per cent. are proportional no longer to the surface but to the body weight.[1]

Practically, the weight and the surface of the human body are far from being in proportion to the height; the more the latter diminishes, the more is the surface relatively increased and consequently, the alimentary needs. Small people eat, then, more than big for a like weight; they also excrete a greater quantity of carbonic acid by the skin and lungs (Ch. Richet), they consume

[1] M. Ch. Richet has established in a remarkable way that the loss in calorific energy of animals, and consequently their need of food to a great extent (72 per cent. in the case of man), is proportional not to the weight of the body, but to its surface. Here are some figures for rabbits (*Chaleur animale*, Paris, 1889; pp. 220, 221).

	Calories per kg. per day.	Calories lost per square decimetre of surface.
Rabbits weighing 500 grms.	5495	11·8
,, ,, 2100 ,,	4730	11·3
,, ,, 2300 ,,	3985	10·9
,, ,, 2500 ,,	3820	10·8
,, ,, 2700 ,,	3650	10·5
,, ,, 2900 ,,	3570	10·6
,, ,, 3100 ,,	3320	10·1
,, ,, 3600 ,,	2690	—

By comparing a certain number of observations quoted by MM. Ch. Richet and Lapicque, it is possible to draw up for the human species the following table of the average expenditure of calories in relation to a kilogramme of weight of the subjects and to their surface.

	Weight of Subjects.	Calories per kg. per 24 hours.	Calories per sq. decimetre of surface.
Child (Rübner)	11·8 kgs.	81·5 Cals.	13·43 Cals.
,, ,,	23·7 ,,	59·5 ,,	13·89 ,,
Young man (Rübner)	40·4 ,,	52·1 ,,	14·52 ,,
Man 67 yrs. old ,,	67·0 ,,	42·4 ,,	13·99 ,,
Workman (Voit and Pettenkoffer)	70·0 ,,	43·2 ,,	14·70 ,,
Japanese student	46 ,,	51·2 ,,	14·30 ,,
,, soldier	59 ,,	43·6 ,,	13·80 ,,
Subject 2 of Lapicque and Marette	73 ,,	41·5 ,,	14·20 ,,

We see that with man, the need in calories varies per kilogramme of the body from simple to double; that, on the contrary, this need is almost constant if it is compared with the surface. It would be about thirteen to fourteen calories per square decimetre of surface according to these numbers, which are evidently too high.

more oxygen and appear to have need of a greater *relative* quantity of albuminoid substances. Rübner has somewhat arbitrarily drawn up the table of calories necessary to the adult according to the weight of the body if he is neither thin nor fat :—

Weight of Body in kilogrammes.	Energetic value of Foods in calories per day.	Calories per kilogramme.
50	2472	49·4
60	2792	46·5
70	3094	42·2
80	3372	42·1

All these figures of Rübner are too high, especially if they are applied to fat people with whom the nutritive exchanges are less powerful than with the thin, and who are usually less active. They should, we consider, be reduced from 9 to 15 per cent. according to the degree of stoutness of the individual and to his habits.

It is certain that the necessary alimentary energy per kilogramme of body weight to maintain functional activity varies with the weight of the subject and diminishes very notably in proportion as this weight increases. In subsequently calculating the average number of calories consumed per day and per kilogramme by subjects weighing 70 kgs., Rübner found 2,303 calories, that is about 33 calories per kilogramme. In making the same calculation for subjects weighing on an average 65 kgs. I have myself found 2,500, that is 37 calories per kilogramme of body weight in our temperate climates.

M. Bordier's table (p. 380) and other analogous calculations show that between the ages of twenty and thirty a man normally weighs, in kilogrammes, nearly the number indicated by his height expressed in centimetres, minus 105. Thus a man of 165 centimetres in height should weigh *about* 60 kgs. But observation proves that a normal individual may lose a tenth of his height (6 kgs. in this case) without wasting, the loss being at the expense solely of the fat and water of his tissues, very little at the expense of his flesh. Reciprocally he may increase by a tenth of his normal weight without tending to become obese. For the height of 1·65 m. we shall have then :—

Normal weight[1] . . .		60 kgs.
Minimum weight . . .	60 kgr. – 6	=54. „
Maximum weight . . .	60 „ + 6	=66. „

Regimens should be in proportion *to the normal weight* of the individuals with these considerations taken into account.

[1] Weight taken in the morning fasting, after having emptied the bladder and the intestine.

The preceding calculations, which endeavour to connect regimen with the height and weight of individuals, refer only to the adult. They do not apply either to a child or to an adolescent, either to the old or to a woman. Of the regimen of these people we shall treat shortly.

Variations of Regimen according to Climate and Season.—In cold climates and seasons the heat radiated, and loss of heat by breathing being greater, a richer alimentation for the same amount of external work is necessarily required; and reciprocally, a poorer alimentation will suffice in a warm country. And as it is the heat radiated or rendered latent by evaporation of the water from the lungs or of sweat, which diminishes the proportion of energy at disposal and capable of being transformed into work, it follows that each time this loss by cooling is slight, the individual will be able to live, discharge his functions and work equally well with a smaller alimentation. I have seen, for example, some Catalonians live on a regimen which provided them with no more than 1,900 to 2,000 Calories. They were none the less good tempered, healthy and muscular and did a great amount of work.

During his voyage on *La Sémiramis*, M. Lapicque [1] estimated the food of the Abyssinians of Ghinder (altitude—900 metres) living in an average temperature of about 17°, at 50 grms. of albuminoids, 30 grms. of fats and 360 grms. of starchy or sugar substances per day for men of an average weight of 52 kgs., which gives 1,950 Calories gross (or 1,823 utilizable), that is about 38 Calories per kilogramme per twenty-four hours. In the lower regions of Abyssinia, at Massaouah, in the average temperature of our summer, working men received 2,200 Calories per day (rectified calculation): subtracting only 400 Calories for average work, there remain 1,700 Calories for maintenance allowance, that is 32 Calories per kilogramme per day. In Singapore, servants and Javanese paddlers received per day food corresponding to 2,050 Calories for an average weight of 52·6 kgs. If we subtract 400 Calories for indispensable current work, 1,650 Calories remain for the maintenance allowance, that is 31 Calories per kilogramme per day in this very warm climate. The quantity of albuminoids in their maintenance allowance did not perceptibly exceed 1 grm., and the ternary substances 4·5 grms. per kilogramme of body weight, when they were not working, and 6 to 7 grms. when they were working (Lapicque).

In a course of very interesting researches entitled *Influence des climats et des saisons sur les dépenses de l'organisme chez l'homme* [2] Prof. Maurel, of Toulouse, arrives at the following conclusions:—

[1] *Bull. Soc. biologie,* March 4, 1893 and Feb. 3, 1894.

[2] See *Archives de médecine navale,* t. LXXIV, p. 366, t. LXXV, pp. 5, 81.

In intertropical countries the maintenance allowance is almost *five-sixths* of that of temperate climates.

For the maintenance allowance in our climate, the quantity of assimilable nitrogenous matters in the allowance should not fall below 1·2 grms. per kilogramme. It should remain about 1 grm. in intertropical climates.

The fatty bodies should never exceed 1 grm. per kilogramme of the weight of the body, especially in hot climates.

Starchy bodies and sugars rise from 3·8 grms. to 4 grms. in these same climates.

Alcohol, even in such beverages as wine, cider and beer, should not exceed 40 to 50 grms. per day.

Moderate work increases by about one-sixth the losses corresponding to the maintenance allowance.

The hot season of hot countries corresponds to average temperatures of 25° to 30° (Lowlands of Guiana, Antilles).

The cool season of the intertropical zone and *hot season of the temperate countries* give a monthly average of 20° to 25° (winters of Senegal, Madagascar, Tonkin, Laos).

The summer of cold countries, or *the average season of temperate countries*, corresponds to an average of 10° to 20° (France, Central Europe, Algeria in winter).

The winters of the temperate zone and the intermediate season of cold countries have an average temperature of 5° to 10°.

The winter of cold countries corresponds to a monthly average lower than +5°.

Here is the table given by M. Maurel for the maintenance allowance in hot seasons and hot countries, the *cold season* and *cold countries*, and finally the intermediate climates:—

MAINTENANCE ALLOWANCE ACCORDING TO CLIMATES.

Climate and Seasons.	Number of Calories per kilogrm.	Calories per 24 hours: Man weighing 60 kgs.	weighing 70 kgs.	weighing 80 kgs.
		Calories	Calories	Calories
Hot season of hot countries .	30	1800	2100	2400
Cold season of hot countries and summer of temperate countries	35	2100	2450	2800
Intermediate season of temperate countries and summer of cold countries	40	2400	2800	3200
Cold season of temperate countries and intermediate season of cold countries	45	2700	3150	3600
Cold season of cold countries	50	3000	3500	4000

For the best application of these data, the weight of the sub-

jects should be normal, that is to say equal in kilogrammes to that of the height reckoned in centimetres, diminished by 105, from the age of 20 to 30, and by 100 from 40 to 60. For the allowance for work, the number of calories should be augmented from 400 to 1,400 according to the cases.

In cold climates, where muscular exercise becomes a necessity, meat should form a part of the regimen, in a quantity relatively more abundant and to a greater degree in proportion as more work is performed. If needful, man may in this case consume with advantage a certain proportion of alcoholic liquors.

Liebig, in order to give an account of these facts which had been incompletely studied in his time (1843), had advanced his theory called that of the *plastic and respiratory* foods, a theory too absolute, it is true, but of which we must retain one part: "as long as blood contains with its albuminoids," he said, "matters having a great affinity for oxygen, this agent could not exercise its destructive action on the essential principles of our tissues. . . . Starch, sugar and fat serve to preserve the organs and to maintain the temperature of the body. . . . Whilst the nitrogenous principles of the foods preserve the organs and *thus maintain the production of energy, the non-nitrogenous principles maintain respiration and heat.* These last are then *agents of respiration*. . . . As the faculty which bodies possess of evolving heat by their union with oxygen depends on the proportion of their combustible elements to equal weights, it is easy to calculate approximately the value of these bodies as producers of heat. . . . Of all the agents of respiration fat is the best, and muscular tissue the worst." (J. Liebig *Lettres sur la chimie*, French translation, pp. 141, 148.)

Such is Liebig's opinion on this interesting point. He does not say that muscle while acting and being consumed does not produce heat, but only that it is of all foods the one which produces the least; that if we are trying to produce heat it is to the fatty matters and carbo-hydrates that we should turn; and that, on the contrary, it is to the nitrogenous matters that we must revert if we wish to obtain work. As has been seen, these conclusions are not accurate, for we know to-day that work is a form of energy which is actually derived from all parts of the foods, nitrogenous and especially non-nitrogenous. But the meat consumed in order to produce this work having above all the rôle of *stimulating* and *regenerating* the muscle, remains, as Liebig remarked, rather a *plastic than a respiratory food.*

Thus when during a cold season or in a glacial climate it is a question of resisting the cold, it is the ternary foods, especially the fats and alcohol itself, which a universal instinct increases in the alimentation. We know that the Esquimaux and Greenlander, when possible, drink with relish several litres of fish oil

per day, and that in winter cruises and fishing expeditions in the North Sea, alcohol becomes an almost indispensable food to the sailor. Reciprocally, in tropical climates and hot seasons, fats, these great producers of heat, form instinctively only a small part of the daily ration, and water slightly sweetened and acidulated takes the place of alcoholic liquors. In these hot climates, on account of the abundant evaporation which takes place from the surface of the body, and which maintains the temperature of the organs at 38°, the regimen is instinctively enriched by herbaceous foods, acidulous fruits, and aqueous beverages which make up for the water evaporated by the skin to refresh the blood etc.; to these very light foods may be added as a sort of constant factor the proportion of proteid matters which are indispensable to the maintenance of the tissues. What is necessary in these climates is to avoid too fatty or too starchy foods, to partially abstain from fermented liquors and particularly from pure alcohol which, with the excess of nitrogenous foods, would lead much more rapidly than in cold climates, where they are utilized at once, to congestions of the brain and liver. But, and this is interesting, for the same habits, the same occupations, and an analogous yield in work, the workman consumes almost the same proportion of proteid matters and takes nearly the same quantity of them from animals and plants, *whether the climates be cold and damp or hot and dry.* Only the rate of ternary principles rises in cold climates. This is particularly demonstrated by the facts which I have summed up in the following table, relating to agricultural labourers in the coldest and hottest parts of France. We have already stated the same facts for workmen of other countries (p. 93 seq.).

Agricultural Labourers of the Department du Nord (France) according to Gasparin.

Per Day.	Albuminoids.	Fats.	Carbo-hydrates.
Of animal origin	29·3 grms.	99·8 grms.	1005·7 grms.
Of vegetable origin	128·1 ,,	20·1 ,,	14·3 ,,
Totals	157·4 grms.	119·9 grms.	1020·0 grms.

Agricultural Labourers of the South of France (Narbonne) according to the Author.

Of animal origin	27·0 grms.	39 grms.	737·9 grms.
Of vegetable origin	130·3 ,,	46·9 ,,	1·2 ,,
	157·3 grms.	85·9 grms.	739·1 grms.

Thus, living in very different climates, the agricultural labourers of the neighbourhood of Lille consume 157 grms. of alimentary albumin per day, like those in the neighbourhood of Narbonne; but, on the other hand, the former resist their cold and rainy climate by adding to their ration 315 grms. of fatty and starchy substances more than the latter. For the Astrakan carpenter (see

pp. 94 and 95) 144 grms. of albuminoids per day are sufficient, but he also requires 766 grms. of ternary matters, *not including alcohol.* The peasant of Prasnysz (Northern Russia) requires only 135 grms. of albumin in the winter, but his ration contains then 955 grms. of ternary matters, *still subtracting alcoholic drinks* (Smolensky). The German wood-cutter of Liebig is contented with 135 grms. of albuminoids per day, but he receives (not including fermented drinks) 1,084 grms. of fatty or starchy principles. It is then these principles, and particularly the fats, which man instinctively accumulates in his regimen when he has to resist cold. As to mechanical work, it is provided to a great extent by fatty bodies and starchy substances, but not entirely, for the albuminoids in the allowance increase with work although much less than the ternary bodies, and not in proportion to the fall in temperature or to the glacial climate, but rather to the fatigue of the workman. And even, according to the figures published by Russian authors, it is in summer and not in winter that the peasant consumes the most meat and fish.

These facts of observation, collected apart from all preconceived theories, agree well with those determined by experiments in the laboratory. A man weighing 76 kgs. fasting and at rest, excreted the following quantities of carbonic acid and urinary nitrogen, while living six hours successively in the gradually decreasing temperatures which are indicated here :—

Temperature.	CO_2 eliminated.	Total nitrogen of the Urine.
27°	160·0 grms.	4·0 grms.
24°	164·8 ,,	3·4 ,,
16°	158·0 ,,	4·0 ,,
9°	192·0 ,,	4·2 ,,
4°	210·7 ,,	4·2 ,,

In proportion, then, as the surrounding conditions become cool, a man does not lose sensibly more of nitrogenous substances, and consequently does not consume more of them, but he burns more and more carbon, borrowed from ternary matters, which disappear proportionally to the cooling of the surrounding conditions, matters, the need of which, in consequence, is felt more and more if the temperatures of the surroundings diminish progressively. It seems, however, that the remark has been made that *for equal weight and equal work* the inhabitants of tropical countries eat nearly as much as those of cold climates (Eykmann, Lapicque). The enormous evaporation by the skin in very hot climates, would perhaps explain the necessity for an alimentation which is sufficient to make up for this loss of latent heat.

XXXV

ADAPTATION OF REGIMEN TO AGE AND FUNCTIONS OF THE INDIVIDUAL—IDIOSYNCRASIES

BY constantly keeping our eyes upon the adaptation of diet to the circumstances in which the healthy individual lives and develops, we find other conditions than those of the surroundings, of climate, of need for the production of mechanical or intellectual work, of the weight of the subject, racial customs, etc., which necessitate special regimens. Age and sex lead to very important modifications in alimentation from birth to old age.

The child discharges his functions and breaks up compounds more actively than the adult. It needs for an equal weight more air, more albuminoids and more fats because it gives off, per kilogramme of body weight, more carbonic acid; it produces more urea and more heat, as the following table indicates:—

Age of Subject.	Average weight of Body.	Urea per day and kilogramme. (*Camerer.*)	CO^2 per kilogramme. (*Scharling*).
7 months	7 kgs.	—	—
18 "	9 "	1·35	—
3 years	13 "	0·9	—
5 "	16 "	0·76	—
7 "	19 "	0·74	20·0
9–10 "	25 "	0·69	15·00
13–15 "	33 "	0·60	14·16
16 "	36–45 "	0·50	12·7
19 "	56 "	—	—
25–30 "	65–70 "	0·50	—
35 "	65–70 "	—	12·0 grm.

In trying to fit alimentation to the losses of the system, Flügge has been able to estimate, as follows, the alimentary necessities at the various ages of life:—

Necessary Alimentary Principles according to Age.

	Av. weight of Body in kilogrammes.	Per day and per kilogramme of weight. Albumin.	Fats.	Carbo-hydrates.	Calculated in Calories per kilogrm.
	kgrs.	grms.	grms.	grms.	
End of the 1st week	3·5	3·7	4·3	4·4	73·20
5th month . . .	7·6	4·5	4·8	5·6	86·02
12th „ . . .	9·6	4·0	4·0	8·0	86·40
18th „ . . .	10·8	4·0	4·0	9·0	90·5
2nd year . . .	12	4	3·5	10·0	89·9
4th „ . . .	15·1	3·8	3·0	10·0	84·5
6th „ . . .	18·0	3·1	2·2	10·0	74·2
10th „ . . .	26·1	2·5	1·6	9·0	61·0
14th „ . . .	40·5	2·0	1·0	7·5	48·3
20th „ . . .	65·0	1·8	0·9	6·0	44·5

Alimentation then, in infancy and adolescence, ought to be intensive. It ought also to be specialized at different ages, as will now be shown.

Regimen of the Newly Born.—The best regimen for the newly born child is maternal suckling. Moreover it needs to be normal and regularly conducted. The young child should be suckled during the first weeks every two hours, then every three hours during the day and twice again during the night. Consequently, in all, during twenty-four hours, suckled eight times with about 80 grms. each time for the first month, with 100 grms. the second, 120 grms. the third, and 140 to 150 grms. from the fourth to the sixth month. At least twice every day the weight of the milk should be verified, and once a week, at least, the weight of the child should be taken. During the two or three first months, it should gain from 28 to 34 grms. per twenty-four hours.

I have stated (p. 178) what were the exterior characteristics of good nurses. The best age is from twenty-one to thirty-one years. Above all they ought not to carry any mark or stigma of syphilis, scrofula, saturnism or of tuberculosis. Their milk should be abundant, gushing out of the nipples under slight pressure and in several jets. It ought to be creamy and not present under the microscope too many white globules.

In default of woman's milk, we should, when possible, have recourse to ass's milk, and better still to that of a mare. It should be unboiled and collected with all the antiseptic care possible (washing the udders and rubbing the hands with soap, then with boiled borated water and with pure boiled water ; sterilization of the jars and glasses, etc.) Infants may be induced to take this milk either in a teaspoon or, which is better, in a cup, in small draughts.

If it is not possible to obtain ass's or mare's milk, it is better to have cow's milk rather than goat's, which is too rich in casein and butter, too fragrant, too different from human milk in its

constitution and the special nature of its proteids. This milk must be obtained from a healthy cow, 3 or 4 years old, having calved at least two months. It must be mixed with its volume, or half its volume (according to the greater or less age of the child) of a solution of 5 parts of sugar of milk, if necessary saccharose, in 100 parts of boiled water. This mixture of milk and sweetened water should be sterilized at 100° in a *water bath* in one of the special apparatus already described (p. 187) and heated to boiling point 15 to 20 minutes before being given lukewarm to the child. Each bottle thus sterilized should contain the amount of one suckling, say 100 to 120 cc. The nursling should receive daily from 175 to 180 grms. of milk per kilogramme of weight.

Good milk sterilized at home, and commercial sterilized milk of good brands (provided this latter be not too old) is easier to digest than fresh unboiled milk. But this has been accused of constipating infants and rendering them anæmic and pale. It is sometimes necessary to give to these puffy babies a little raw pulped meat. The objection that boiled and sterilized milk loses its salts of lime, the citrate precipitating and disappearing by boiling, is purely theoretical.

Rübner and Heubner have remarked that if the child receives an insufficient quantity of nourishment, it only loses its fat, whilst it continues to fix the albuminoids, and its flesh increases in weight.

For children fed artificially from their birth, Biedert advises 200 grms. of a mixture composed of 1 part of cow's milk, 3 parts of decoction of oats and 4 grms. of sugar being given daily, per kilogramme of weight, during the first two months. This mixture would correspond, per litre, to 9 grms. of albuminoid substances, 9 grms. of fats and 50 grms. of sugar, and furnish 326 Calories.

Heubner prefers to add to 2 volumes of milk 1 volume of decoction of flour of wheat or oats (a coffee spoon of these flours per 250 cc. of water). Of this mixture, the child is given :—

During the 1st month	600 cc. per day
From the 4th to the 8th week . . .	800 cc. ,, ,,
From the 8th week onwards . . .	900 cc. ,, ,,
After the 3rd month	1 litre ,, ,,

Heubner's mixture corresponds to 595 Calories per litre. This quantity then will provide a child of three months, weighing on an average 6 kgs., with about 100 Calories per kilogramme per day instead of 40 which the adult receives, that is to say more than double; but we know (Ch. Richet, Trav. du laboratoire, t. I *Recherches de calorimétrie*) that the child loses per kilogramme per day 96 Calories, while the adult only loses 42, figures which well correspond to the preceding.

The possibility of thus feeding the nursling artificially and without too much danger to him, removes the importance of this

question : Can an invalid mother continue to suckle her child ? We shall reply no, if it can be done otherwise, or if the malady is grave, the milk exhausted, thin, insufficient ; no, if the child does not increase in weight, if it has green diarrhœa ; yes, in the case of a passing febrile complaint, and if the mother and child do not suffer too much from it and only temporarily.

To the child who remains at the breast, may be given, starting from the seventh month, either cow's milk diluted with water, sterilized by heat and slightly sweetened, or light broths, lacteal flours, and other mixtures of concentrated milk with torrefied and pulverized bread, various flours, a little cocoa, etc. He may also be allowed panadas of toasted and grated bread accompanied by a little fresh butter or yolk of egg. The use of these preparations is increased from month to month until weaning, which then comes about gradually and of itself, from the twelfth to the eighteenth month, according to the seasons.

At this time the child may be given sterilized or boiled cow's milk, sugared or salted, in which, when warm, are mixed flour of oats, wheat, barley, feculæ of rice, arrowroot, the pulp of potato, lightly roasted in the oven, rusks in powder, etc. We then go on to yolks of eggs boiled or mixed with milk.

Prof. Maurel, of Toulouse, fixed the allowance of nourishment during the first four months at 75 Calories per kilogramme, which amounts to about 102 grms. of cow's milk, per kilogramme of weight per day. M. G. Variot, as a result of his observations on the children in the dispensary at Belleville, gives the following figures for the alimentation of the child with sterilized cow's milk :—

Per Day.	Pure Milk.		Per Day.	Pure Milk.
1st week	240 grms.	This milk must be diluted with $\frac{1}{3}$ of boiled water	3rd month .	960 grms.
2nd ,,	360 ,,		4th ,, . .	1080 ,,
3rd ,,	415 ,,		5th ,, . .	1280 ,,
4th ,,	545 ,,	This milk must be diluted with $\frac{1}{4}$ of boiled water	7th ,, . .	1440 ,,
6th ,,	672 ,,		9th–12th month	1600 ,,
2nd month	758 ,,			

Give the bottle every 2 hours during the first weeks, every $2\frac{1}{2}$ hours from the second to the fourth month, and then every 3 hours. I must add here that I have seen some children, from 20 months to 2 years, with whom milk diet did not agree, who refused all alimentation in the form of milky or vegetable broths, who became weak and thin and who, put on a diet of soups made from boiled or grated roast or raw meat, took it with avidity and increased in weight from that time. One sees that it is not possible to have regimens with too arbitrary rules even for children.

Children from Two to Fifteen years old.—These facts, as well as the observation of the results of alimentation followed apart from

all preconceived theory, lead me to think that *if milk ought to be made the foundation of the feeding of the child in the first two or three years of its life, muscular tissue may and ought to be given to him, cooked or raw, from the middle of the second year although in a very moderate quantity:* roast mutton or lamb, beef, minced ham, rather than veal or chicken, with the addition of boiled or buttered eggs, creams and paps, rice, vermicelli in soups, butter, thoroughly ripe fruits, cooked or raw non-fermented cheeses, stewed potatoes, green vegetables, cocoa, etc. The exclusive use of milk makes fat, puffy, lymphatic children, capable of standing little. This state is further accentuated by the abuse of sweetened dishes.

It is also necessary at this age to avoid giving foods which are highly seasoned, and too much salted : fat fish (herrings, eel, salmon) dry fish, salted or smoked, crustacea, snails, cabbages, mushrooms. We must also avoid giving the child sauce with wine, vinegar or spices, raw, dry, unripe or too acid fruits. Fermented cheeses, alcoholic liquors of every description, coffee and tea should not be allowed.

From the second to the sixth year the child gets accustomed to ordinary food : but it is still necessary to deprive him of spices, sweetmeats, wine, liqueurs and coffee. We should only give him sweetmeats exceptionally. Milk, eggs, roast meat, vegetable purées and bread ought to make the foundation of his alimentation. From six to fifteen years, the child ought to be provided with nearly twice as much albuminoid matter, per kilogramme of body weight, as the quantity which would correspond to the needs of the adult of the same weight. In fact, the elimination of urinary nitrogen is per kilogramme per day 0·74 grms. in the case of a child of two years, 0·61 grms. in that of one from three to four, 0·4 grms. in one of five to seven years, whilst it is only 0·23 grms. in an adult. The fats also ought to be proportionally more abundant in the case of a child, who becomes cold, as we know, so much quicker than an adult. Here are, according to different authors, the quantities of alimentary principles recognized as being necessary to the different ages of childhood, calculated for twenty-four hours and for individuals of average weight :—

	Albuminoids.	Fats.	Carbohydrates.	Calculated in Calories.
	grms.	grms.	grms.	
Children from 6 to 15 yrs. (average according to Voit)	79	37	250	1639
Children from 5 to 16 yrs. (average according to Camerer)	70	40	236	1627
Boy of 10½ yrs. weighing 25 kgs. (Uffelmann)	65	46	206	1539

These figures appear to us a little high.

From three to seven years the child should receive food every four or five hours. His diet should be little stimulating and little varied, neither too sweet nor too salt, but sufficiently nitrogenized, at the same time rich in bread and vegetables, which among other things bring the supplement of mineral salts needed.

Starting from five or six years he may have watery wine, cider and beer. But from seven to twelve years he ought still to avoid dishes which are stimulating, heating, too nitrogenous and too highly spiced, and he should not be given either too alcoholic beverages, or coffee.

In the case of the growing child, certain mineral elements, especially salts of potash and lime, as well as organic phosphorus, become particularly necessary to the growth of the tissues. Bread, cereal flours, milk, brains, fish, seed vegetables, broth, furnish these materials in considerable quantities. We must not lose sight of the fact that from its birth to one year old, a child ought to fix 600 grms. of mineral substances in his bones, and from 120 to 150 grms. the following years. He needs the first year nearly 0·5 grms. of lime a day.

Adolescence ; Puberty.—The adolescent ought to have the free use of bread, eggs, meat and foods of every kind if he digests them well ; but he ought still to avoid spiced dishes and too generous wines. In the case of the young girl or boy it is useless indeed to provoke prematurely the hasty development of the functions of reproduction which would stop or would interrupt the normal growth and react on the other functions. The best stimulant of the appetite at this age is fatigue for boys, moderate exercise and walking in the open air for girls.

The establishment of puberty is generally the establishment of exceptional needs of nutrition. From sixteen to eighteen years a boy eats as much as an adult, sometimes more (Panura, Uffelmann). He has need of a great excess of meat. The young man ought then to be able to satisfy his appetite fully. This is not perhaps the case with the boys in our *lycées :* the very big boys receive administratively 1,500 grms. of trimmed and boned meat per week, or 213 grms. per day ; the big boys (5th and 4th), 170 grms. ; the average boys (3rd and 2nd), 150 grms., and the little ones (1st) 115 grms. on an average per day. From the 5th form upwards it is too little for the big boys. Fish, milk, dry vegetables, cheese and eggs should complete this regimen. Moreover we must see that young people really do receive the ration allotted to them by the rules ; that the quality of the food is good ; that the meat is roasted rather than boiled, that dry vegetables are prepared with care and that the food is distributed regularly. From 14 to 20 all work, including intellectual work, is accompanied

by an enormous expenditure. It is the age when the body takes its definite form, becomes virile, acquires strength and wastes. Only the use of stimulants, spices and fermented liquors then should be restrained.

We have shown in Part I of this Work the quantitative and qualitative composition of the daily allowance for maintenance for the adult, whether he remains at relative repose or whether he is at work, and in the preceding chapter we have seen that intellectual work represents an effort which should be covered by a supplement, but by a minimum supplement, of food. Sobriety in the choice of dishes and their easy digestibility is more the safeguard of health for the studious man than for the sportsman or the manual worker. United with moderate exercise, if the original constitution is normal and the life regular, it puts off old age for a long time.

Sex.—The same rules apply to the adolescent boy and to the young girl ; still more in the case of the latter, when puberty is becoming established, must we see that she eats healthily and abundantly, especially flesh foods, fish, vegetables in grain, ham, eggs, cheese. At the time of the periods, women should avoid stimulating dishes, crustacea, spices, coffee, wine and too alcoholic liquors.

With the adult woman, except in the very special cases of which we are going to speak, it is known that the regimen should be about four-fifths to five-sixths of that of a man[1] ; as we have already said, whether she does not work or whether she does, in which case, the regimen should follow in proportion that of a workman living under the same conditions.

Pregnancy.—During pregnancy the woman should eat that which pleases her most, especially in the course of the first months, when she is often subject to nausea and vomiting : coffee, tea, cocoa, extracts of meat, game, fruits, beer, wine, etc., are not unsuitable to her if taken in moderation. But a woman with child ought to lay particular stress on bread, seed vegetables, eggs, milk, meat and fish. Starchy or fatty foods ought to be taken in moderation, for the liver and heart have a tendency at this time to be invaded by fat. As meat forces the congested liver to supplementary work in eliminating toxins arising from muscular tissue, this latter ought to be entirely stopped if even *traces* of albumin should appear in the urine. Milk diet should be strictly adopted if there is any danger of eclampsia.

It is a mistaken idea of Prochnovnik, and other accoucheurs before him, that the child develops less well if the mother is

[1] Camerer fixes the alimentary needs of a woman of the same weight as a man at 84 to 90 per cent. Schmidt allows the figure 89 per cent. I do not know on what experimental data they found their opinions.

deprived of meat or other foods. Generally she alone suffers from it and the fœtus arrives at the appointed time almost as if the mother had not suffered.

A pregnant woman should avoid as much as possible acid and indigestible foods, too alcoholic and too abundant wines, too highly spiced and salted condiments, coffee, and even strong tea, at times corresponding to the end of the sixth, seventh and eighth month of her pregnancy.

These foods favour premature accouchements.

Immediately after delivery the woman may be fed on milk, eggs and biscuits ; the following days on bread, milk, meat in small quantities. She can then return to the diet which she prefers, avoiding nevertheless indigestible dishes, cabbages, and during the first two or three weeks, seed vegetables, and above all, particularly haricots.

Wet-nurses.—The diet of wet-nurses should be watched, but not altered in nature and quantity to such an extent that it becomes an inconvenience or too great a disturbance of former habits. Women who suckle should be given meat, fish, brains, etc. ; allowed fatty bodies under all forms and in abundance if they can digest them well ; milk and milk foods including cheese ; starchy foods, such as potatoes, bread, rice, seed vegetables, green and dry peas, lentils, etc., which excite the lacteal secretion, but not dry haricots ; vegetables (with the exception of cabbages, cress, garlic, leeks, onions, mushrooms, salads and sorrel), very ripe fruits, and better still cooked fruits ; meals of good brands and casein powders, provided that their taste pleases and that they are not too stale, may also be useful.

To the vegetables quoted above as not suitable for nurses or nurslings let us add too highly spiced or too salted dishes, strong cheeses, salt fish, too piquant pork, butcher's meats, crustacea, mussels, herrings, anchovies, etc.

It is well to allow wet-nurses to take in abundance water mixed with a little wine or cider, but to forbid them to drink beyond *half litre of good wine or a litre and a half of beer or cider :* never alcohol or liqueurs.

The woman who suckles ought to feed herself well, but not to excess : a daily alimentation furnishing her with 150 grms. of albuminoids, 100 grms. of fat and 450 to 600 grms. of carbohydrates, composed especially of bread, meat, dry and starchy vegetables, fatty bodies, beer, etc., is favourable to the production of milk. Here is an example of this allowance where we have calculated for one day the weight of the constituent alimentary principles of the allowance :—

	Weight.	Albuminoids.	Fats.	Carbo-hydrates.
	grms.			
Bread	600	50·0	5·1	300
Meat	400	80	28	2
Beans, peas, lentils	100	23	2	59
Potatoes . . .	150	2·4	0·5	30
Butter	65	—	60	—
Beer ($1\frac{1}{2}$ litres) .	—	7	—	20
		162·4	95·6	411

The litre of beer or 110 grms. of meat may be replaced by 1 litre of milk, and the vegetables and fat by eggs.

Weak tea and coffee in small quantities may be allowed. The wet-nurse may give the breast to the suckling when her periods return if her appetite keeps good, if the child continues to gain weight, if it does not get pale and has no diarrhœa or exanthemata. It is not the same when the woman becomes pregnant again. In this case it is necessary as soon as one can, to give the child another wet-nurse, or to supply the deficiency of the milk by a different sort of milk. As regards chlorotic, anæmic, and neurasthenic women, in their own interest and in that of the child, it is preferable that they should not suckle.

Menopause.—The time when menstruation ceases necessitates some precautions in the choice of foods. The woman ought only to take those which she digests the best, to avoid alcoholic drinks, spiced dishes, excess of meat, condiments and too great abundance of foods.

Old people.—Among old people, alimentation should be reduced but not to such an extent that it would appear to demand the impairment of their activity, because on the one hand, the radiation from the skin and the caloric loss by pulmonary and cutaneous evaporation remain nearly normal in their case; on the other hand, the assimilation being less regular, the smaller utilization of the foods demands that these be taken in relatively larger quantities.

Forster[1] has given the following figures as a measure of the average daily ration of aged people from 65 to 80 years :—

	Albumins.	Fats.	Carbo-hydrates.	Corresponding Calories.
Men	92	45	340	2173
Women	80	49	270	1883

Too abundant meals, dishes difficult to digest or masticate, foods too rich in fat, not sufficiently nourishing or too herbaceous, should be avoided by old people. Broths and foods easy to take, legu-

[1] *Zeitsch. f. Biolog.*, Bd. IX, p. 401.

minous meals, milk, grated meats, eggs, well cooked doughs, creams, very ripe fruits, coffee and tea are particularly suitable for them. Wine should be allowed to the aged. and even in a pretty large quantity unless there are any evident signs of arteriosclerosis.

Milk, easily digested meat, dishes to which by long usage they are accustomed and which do not require much mastication, are to be recommended at this age. But we must avoid an excess of bread, vegetables, potatoes, all of which give but little nourishment though large in bulk, of all that is indigestible, etc., as well as the repeated use of too alcoholic beverages.

Idiosyncrasies.—Rules relative to alimentation cannot be absolute. For reasons which elude us, but in which heredity and custom enter in very large measure, there are some individuals who require food in greater or smaller quantities ; also some who cannot accustom themselves to the most natural foods.

There are large and small eaters, races which need an abundant nourishment and others a moderate one. The appetite is a function which develops when cultivated, and *vice versa.* After the Siege of Paris, many persons had some difficulty in resuming their former alimentation ; it had become too abundant for them. Inversely, comfortable habits create artificial needs, especially when they have been followed for several generations.

From the point of view of the nature of the foods, particular dispositions or *idiosyncrasies* may be extraordinary and very unexpected. Fonssagrives has quoted a family in which eggs, no matter in what form they were prepared, led to attacks of choleraic indigestion. I knew a young officer in whom the yolk of an egg, even when added to his food in a very small quantity, and unknown to him, led to a kind of suffocation, then indigestion. This condition persisted from his childhood without his ancestors or his sisters having shown anything similar. Persons have been known to be taken with derangement of the bowels when they tried to eat bread, even the crumb of it, introduced, without their being warned, into stews, when they could digest feculents and potato broths.

There is known to be an insurmountable repugnance among certain subjects for dishes generally liked by every one ; shell fish, crustacea, fish, pears, cheese, truffles, strawberries, etc., and an interesting fact is, that these idiosyncrasies are sometimes hereditary and peculiar to families as if they were connected with a constitution in which the cellular protoplasms, transmitted by progenitors, showed a special lack of adaptability.

XXXVI

INSUFFICIENT REGIMENS—EXCESSIVE REGIMENS—OVERFEEDING

WE have seen (p. 184) that the alimentary allowance suited to maintain the adult at rest in a state of health and without loss of weight, ought to contain *at least* per day :—

Albuminoids	78–82 grms.
Fats	50–60 „
Carbo-hydrates	380–420 „

an allowance which represents in calorific energy about 2,220 units.

These figures agree sufficiently with the losses in Calories and minimum work (calculated in heat) of the adult at rest. The weight of 80 to 82 grms. of proteid matters also meets the excretion of urea and other nitrogenous matters which is produced in the course of the first days of complete abstinence, and which corresponds to the destruction of 78 to 80 grms. of albumin per twenty-four hours. But such a diet is quite the limit of the indispensable daily needs of the system. As soon as the quantities of each of the alimentary principles fall below the above figures, the individual wastes. He destroys first, not alone, but principally, his reserves of fat ; he afterwards draws from his muscles and plasmas the matters which are lacking in the foods ; and when the fats are almost completely absent, the albuminoids of the tissues themselves serve as a combustible to maintain the heat indispensable to life ; from that time the muscles shrink rapidly, the bones become rarefied and all the tissues waste at once. It is the regimen of inanition or of poverty.

When man or animals are subjected to complete abstinence, their temperature remains at first normal for a long time, within nearly half a degree : but for reasons which we have just given, the weight of the body diminishes gradually and various grave troubles are produced. According to Chossat's experiments, when after two or three weeks a warm-blooded animal has thus lost from a quarter to a third of its weight, its temperature from that time falls very rapidly, and death occurs when the blood reaches the temperature of 25° to 26°. Very rarely, the animal dies before the temperature is below 29° and before it has lost

from 40 to 50 per cent. of its initial weight. In the case of a man, at the end of twelve to fifteen days, vomitings and diarrhœa supervene ; the stomach, which lacks the presence of alimentary stimulants, secretes a viscous mucus and becomes little by little incapable of producing a digestive gastric juice. At that moment, if one happens to feed the starving man, there is a risk of provoking in him serious disorders, especially uncontrollable diarrhœa.

In proportion as the experiment is prolonged, the general sensibility becomes obscured, the heart weakens, troubles of the cerebral functions appear : the muscles lose their power ; the blood tends to be extravasated and flows without coagulating on the least wound. It comes to contain less than 100 grms. of red corpuscles (calculated in a dry state) per litre. Water accumulates in the organs where it replaces the fats and the rarefied muscular tissue ; œdema invades the trunk and the brain, finally the unfortunate sufferer from starvation is seized by convulsions and coma, and dies emaciated and resembling a skeleton.

Such is a picture of the disorders caused by absolute want. They may be analysed more exactly by submitting to analysis and weighing day by day various portions of animals and each of their organs, while at the same time we measure the excreta.

According to Chossat, when an animal dies of starvation each tissue has lost the following relative weights :—

Total weight of subject	40–50 per cent.	Liver	52·0 per cent.
Fats	93·3 ,,	Muscle	43·7 ,,
Spleen	71·4 ,,	Heart	46·9 ,,
Blood	75·0 ,,	Bone	16·7 ,,
Pancreas	64·0 ,,	Nervous tissue	8·0 ,,

According to Voit, on the death of the animal, the brain has only diminished 3 per cent.

Pettenkoffer and Voit, and then Ranke, calculated the losses suffered during the first twenty-four hours of fasting by normal beings. They found :—

	Workman weighing 71 kgs.	Ranke weighing 69 kgs.
Losses in albumin	78 grms.[1]	51 grms.
,, fats	215 ,,	204 ,,
,, water	880 ,,	874 ,,

[1] The workman of Pettenkoffer and Voit lost 215 grms. of fat of absolute diet in the twenty-four hours. If he had been provided with 50 grms. of fat he would only have lost the difference, or 165 grms. of fats, which correspond iso-dynamically to 380 grms. of carbo-hydrates. We may therefore say that

Therefore of these two men of almost the same weight, the one, Ranke, who was fat, had lost only two-thirds of the albumin which the other had lost. It is always thus in the case of subjects rich in fat ; it protects against the wear of the muscles.

If starvation is prolonged, the loss in fat bodies becomes almost constant or scarcely diminishes, whilst the consumption of the albuminous tissues decreases notably and continuously during several weeks. Here are, according to Züntz, C. Lehmann, Munk, F. Müller[1] and Lucciani,[2] the losses of weight in albumin and fats of the celebrated fasters Cetti, Breithaupt and Succi who, during the experiment, only drank water :—

		Weight of Body.	Loss in Albumin.	Loss in Fats.
		kgrms.	grms.	grms.
1st. *Breithaupt.*	1st day	59·5	63	162
	2nd „	58·8	62	160
	6th „	56·4	60	160
2nd. *Cetti.*	1st „	56·5	95	170
	5th „	52·6	67	166
	10th „	50·6	60	165
3rd. *Succi.*	1st „	62·4	104	—
	10th „	56·7	51	170
	20th „	52·8	33	170
	29th „	50·2	31	169

In the case of a man thus deprived of all food, the chlorides of the urine diminish rapidly, the salts eliminated fall to 2 grms. per day and stay there. The lime taken from the bones continues to remain fairly abundant.

The urea which remains at 20 or 22 grms. the first days of abstinence, if the individual had continued until then normal and well nourished, falls to 13 grms. towards the tenth day and to 8 or 10 grms. on the twentieth day and continues at this last rate almost until death. The urea increases from 2 to 3 grms. per day if the patient drinks water.

In the case of a dog, as long as there are fats in reserve, the albumin breaks up at the average rate. But, most often, towards the fourth week, its destruction becomes rapid, the albuminous tissues are themselves burnt then, in order to insure calorification, and this phenomenon slightly precedes the end. Bidder and Schmidt had already noticed that in the case of cats

this workman had thus consumed the first day : Albuminoids, 78 grms. ; fats, 50 grms. ; carbo-hydrates, 380 grms. ; figures which agree sufficiently well with those which I have given (p. 388) for the allowance for maintenance in the case of a man at rest, receiving the minimum quantity of albuminoids.

[1] *Virchow's Arch.*, Bd. CXXXI, Supplém.

[2] *Fisiologia del diguino*, Firenze 1889.

(which well fed excrete per day and per kilogramme about 3 grms. of urea) this falls to 2·5 grms. the first day of fasting and to 1·9 grms. the second, and is maintained at about 2 grms. from the third to the fifteenth day with some slight variations. As in the above cases, a notable increase of the weight of the urea announces their approaching death.

As to the carbonic acid exhaled by the lungs, it diminishes by half up to the fourth or fifth day of fasting, then becomes almost constant.

We know from Regnault's and Reiset's experiments and subsequently those of Ch. Richet, that animals consume a quantity of oxygen and produce a volume of carbonic acid so much the larger proportionally as they are small in size, that is to say, in proportion as their surface increases relatively to their weight. The same phenomenon is observed, and for the same reasons, in the losses of fat and albumin. Animals consume fats and proteid substances so much more largely and in consequence become exhausted of these materials by fasting so much more quickly in proportion as they are of smaller size.

Here are two examples :—

Animals submitted to an absolute Diet.	Weight of Body.	Loss of Flesh per kilogrm. of Animal per day.	Fats lost per kilogrm. of Body Weight per day.
	kgs.	grms.	grms.
Dog	31·7	5·2	3·25
Another dog . .	17·2	7·0	3·7
Cat	2·83	10·8	3·6
Another cat . .	1·86	27·16	4·1

In starvation with privation of water, man continues to excrete 250 to 260 cc. of urine per day. He loses from 800 to 900 grms. of water in all (by urine, perspiration and expiration) : it is obtained by the combustion of his albuminous and fat principles as well as by the partial dehydration of his tissues, at least at the beginning.

In alimentation insufficient in amylaceous matters (the best means, as we shall see, of fighting against obesity) there is a disappearance at once of fat and of albuminous principles. In the case of a subject receiving daily an alimentation equal to 1,955 Calories and placed in a state of nitrogenous equilibrium, Miura suppressed a certain proportion of carbo-hydrate principles corresponding to 462 Calories. The subject covered this loss by taking the necessary calorific energy in the proportion of seventeen hundredths from the albuminoids and eighty-three hundredths from the stored fats.

When we reduce proportionally all the nutritive principles, the losses are covered, according to Von Norden, for about 15

per cent. by proteid matters and for 85 per cent by fats. If a subject is placed on half his normal ration the loss of body weight is from 2 to 2·5 kgs. the first week for the average adult. It falls to 1·5 kgs. and 1 kg. the following weeks. The sum of losses in albumin and fats is not increased so much as the total loss, which comprises at the same time the water eliminated. Later, on the contrary, as we have already said, the tissues appear to re-hydrate, there is some œdema and the apparent loss diminishes. This condition of aqueous puffiness has been observed in all cases of want, and partly comes from the abuse which the unfortunate sufferers from starvation make of herbaceous foods or of water which momentarily slightly satisfies their hunger and increases the size of their stomach. With reference to the famine which desolated the centre of France in the spring of 1817, Gaspard (*Journal de Magendie*, t. I, p. 237, quoted by A. Bourchardat) writes : "One saw during the months of April, May and June the meadows and fields covered with miserable people who disputed the pasturage with herbivora ; the result was dropsy of the whole cellular system, without ascitis, without lesions of the liver or the abdominal viscera. From time to time some of these unfortunate ones fell by the roadside ; nevertheless there was no other serious epidemic among them."

Exaggerated Alimentation—Overfeeding.

As we shall see farther on, moderate *overfeeding* is indicated in certain morbid conditions in pretuberculosis and tuberculosis, in some serious forms of hysteria and diabetes and generally in conditions of emaciation due to somewhat diverse causes.

Exaggerated alimentation which must not be confounded with overfeeding is that which exceeds necessity. Its immediate consequence is almost always obesity or arthritis.

We eat too much from system, from habit, from whim because we endeavour to sharpen the appetite by ingenuity, by variety and by alimentary stimulants and finally forcing ourselves to satisfy it fully. But in the same way that a slight daily overdose of alcohol ends at length in creating an alcoholic, a slight excess of alimentation little by little causes arthritis or obesity. The appetite is not a good guide for us : we excite or appease it at will ; it is for many people a function arising from their habits. In particular, in the case of meats the more one eats the more the stomach secretes digestive acid juices ; and the more it secretes, the more one is induced to eat to weaken its impressions and to neutralize the stomachic acidity.

Atony of the stomach, gastric disorders, intestinal troubles, dyspepsia, cramp in the stomach, pyrosis, flushes of heat in the face, hepatic and cerebral congestions, arthritis, gout, gravel,

sometimes albuminuria, vascular hypertension, arteriosclerosis, neurasthenia, etc., attack more or less those who eat too much, particularly too much meat. Among these, the fatty heart most often becomes weak and the brain itself only acts imperfectly, especially during active digestion.

But exaggeration in the supply of the different alimentary principles acts differently upon each organ.

Too abundant muscular tissue leaves in the blood and the tissues an excess of nitrogenous matters almost all harmful: bodies of the uric and pyrimidic series, creatin and its analogies, neurinic bases, undetermined nitrogenous extractive matters, etc., which fatigue the system and at the same time congest the brain, liver, kidneys and heart and become the most active agents of arteriosclerosis.

An excess of meat only makes the muscle of the individual grow slightly if this excess is accompanied by an increase of the ternary principles, particularly fats. Again the excessive production of muscular tissue in the adult is only very slightly influenced by the exaggeration of the allowance of meat, *unless the subject at the same time gives himself up regularly to physical exercises* without nevertheless ever reaching too great a state of fatigue.

Adipose tissue, on the contrary, develops, especially in repose, under the influence of fat foods, and more still if there is an excess of carbo-hydrates and particularly of starchy matters. But it remains established that the abuse of muscular tissue, even lean, may also contribute, although in a lesser degree, to corpulency. Claude Bernard and Sublotin after him, showed long since that animals fed solely on lean meat, produce glycogen in their liver, and we know that all the carbo-hydrates are susceptible in their turn of being changed into fats, in the system, by the loss of carbonic acid.[1]

As to the alimentary fats, they are absorbed and digested, with a little more difficulty than the sugars and starchy matters, but a part of them certainly becomes stored in the adipose tissue.

In cases where we wish intentionally to overfeed an animal or a sick person, the preceding general remarks should not be lost sight of. There remain some practical methods for overfeeding which we will set forth while speaking of invalids, and especially of tuberculous subjects.

It may be advantageous to increase the reserves of fat, for example, in cases of phthisis; but it is necessary to know that overfeeding, whether by carbo-hydrates or meat, only acts in a very feeble degree on those reserves. As we were saying, the

[1] See Soxhlet, *Zeitsch. d. landw. Vereines in Bayern*, 1881. Meissl. *Zeitsch. f. Biolog.*, Bd. XXII, p. 63. Henneberg, *Ibid.*, Bd. XVII, p. 295. Münk, *Virchow's Arch.*, 1895, Bd. XXIII, p. 273. Hanriot, *Comptes Rendus*, 1888.

excess of nitrogenous foods is only transformed into albuminoid tissue : 1st, if the individual takes daily exercise producing average fatigue; 2nd, or if the subject is young and in course of development ; 3rd, if he is convalescent or in a state of inanition. In all other cases, the surplus of nitrogenous foods introduced is eliminated, whilst a greater or smaller accumulation of fats takes place.

In a state of inanition, after hæmorrhages, in the case of consumptives, etc., overfeeding produces quite other effects : the least quantity, like the excess, of nitrogenous matters in this case contributes to make up the deficit without any part whatever of it being withdrawn in order to manufacture fats. This is often observed in the case of convalescents. In all these cases where nitrogenous overfeeding becomes necessary, it is very efficacious : 150 to 250 grms. of meat per day, roast, or better still raw and grated, constitute a practical and average addition to ordinary alimentation. Muscular tissue pulped and swallowed *without being masticated* in bolus form of 20 to 25 grms. each, is much better supported by weak stomachs than in any other form. Fresh lightly cooked eggs, milk (1,500 to 2,000 cc. per day) may partially replace it.

It is better in general, when one can, to have recourse to natural foods than to dessicated or peptonized preparations of meat, the origin and composition of which are often dubious and variable. Besides, these preparations are not always obtained in perfect antiseptic conditions. I must say the same of the nutritive flours and powders of different brands.

If one wishes to effect an overfeeding in fats, fat fish, cream, and butter (80 to 100 grms. per day), potatoes, sugar, a small quantity of wine, vegetable soups, etc., allow of giving to invalids under a relatively light and very digestible form, an important excess of nourishment suited to produce fat.

Here is an example of a diet of average overfeeding :—

		Albumin.	Fats.	Carbo-hydrates.
Grated meat	300 grms.	60 grms.	16 grms.	1·8grms
Wheat bread	300 ,,	25 ,,	2·5 ,,	150 ,,
Green vegetables . .	100 ,,	2 ,,	0·3 ,,	6 ,,
Dry ,, . . .	80 ,,	16 ,,	1·5 ,,	30 ,,
Milk	1500 cc.	53 ,,	45 ,,	60 ,,
Butter	70 grms.	—	65 ,,	—
Wine (or 1 litre of beer).	500 cc.	—	—	80 ,,
Sugar	40 grms.	—	—	39 ,,
		156 grms.	130·3 grms.	366·8 grms.

This allowance easily digested would bring to the system energy equivalent to 3,200 Calories.

With regard to fermented liquors and wine, we have seen how valuable alcohol is in a small quantity in protecting the tissues against the wear and tear provoked by the destructive action of toxins in general, and of what use it may be to replace momentarily fats in the alimentation of invalids (tuberculosis, diphtheria, typhus, etc.) and to provide them in many cases and rapidly with the quantum of necessary energy.

The results of Hirchfeld and Krug's experiments have been: 1st, that if the alimentary contributions exceed by half and more the normal ordinary ration, the weight of the body increases from 3·5 to 5 kgs. in twenty days; 2nd, that at the beginning of the overfeeding, the increase in weight of the subjects exceeds the sum of the united weights of the muscular tissues and of the fat consumed; that in a word, at this moment there is a retention of water. Later, on the contrary, the inverse result is produced. Here are Hirchfeld's observations on this subject. These experiments made on man lasted three weeks.

	Foods calculated in Calories.	Increase in weight of Body.	Increase of Muscles.	Increase of Fats.
		kgrms.		
Man, 30 yrs. old, vigorous, thin, weighing 68 kgs.	2000	3·4	0·87	2·84
Man 49 yrs. old, weighing 56 kgs.	4140	4·5	1·01	3·49
Workman 59 yrs. old, vigorous, muscular, weighing 50 kgs.	4380	5·1	2·03	4·82
Man 51 yrs. old, rather stout, weighing 89 kgs. (lasted 15 days only)	3590	1·3	0·45	1·68
Young man 22 yrs. old, convalescent from typhoid fever, weighing 47 kgs.	3130	4·1	2·80	2·98

These figures show that in the case of the overfed, the quantity of albumin assimilated is essentially variable and depends on the previous state of the subjects. In the above cases, with the young man convalescent from typhoid fever and the workman aged 59, both badly nourished before their overfeeding, there was a gain in muscular tissue of 2·8 kgs. and 2·03 kgs. in 3 weeks, when the obese subject aged 51 only gained 0·450 kgs. and the man of 30 in full health only 0·870 kgs. This enables us to foresee (and experience confirms it) that, if overfeeding is continued, the gain in albumin will diminish considerably and the subject, whilst increasing in weight, will only gain fat.

It is thus that continued overfeeding rapidly becomes an exaggerated alimentation. It charges the liver, the heart, the

kidneys, etc., with fats and is opposed to their regular action. Moreover, if the alimentation is too rich in meat it becomes a source of obstructive waste matters, and of toxins. It congests the hepatic gland and kidneys ; it excites and fatigues the heart by increasing the vascular pressure ; it saturates the tissues with residues all the more difficult to eliminate as it has had the effect of rendering the blood less alkaline and the oxidations less powerful.

XXXVII

EXCLUSIVE DIETS—VEGETARIAN DIET—MILK DIET—MEAT DIET

FROM the earliest times, man has fed on the fruits of the earth and the flesh of animals. But at certain epochs, under the influence of philosophic theories or religious ideas, sometimes on account of hygienic considerations, or even forced by necessity, he has, voluntarily or not, subjected himself to special diets: sometimes eating only fruits and herbs, sometimes adding milk to these vegetables, at other times on the contrary feeding himself almost entirely on meat, or else adopting a mixed diet, but one from which animal flesh was excluded. These exclusive methods of alimentation have led to some hygienic or social results which find applications in the dietetic treatment of invalids and which we are now going to describe.

VEGETARIAN DIET.

To entirely abstain from the flesh of animals was at first a religious practice. The Hindoos, followers of Brahma or Buddha, believed and believe still that the *spirit* or *soul* (ασθμα of the Greeks) can migrate from man to animals, which are our inferior brothers, and it has always been repugnant to those who share this opinion to expose themselves by eating their flesh to a kind of sacrilegious cannibalism. For a similar reason the religion of the ancient Egyptians forbade the use of meat (S. Sharpe). This is the doctrine which Pythagoras brought from that country into Greece, whence it has been transmitted to us modified by time. Its most impressive philosophic echo was heard in the *Emile* of J. J. Rousseau.

But the human race is omnivorous by instinct, by its dentition, by its digestive secretions and by its need of activity. To work quickly and well, the modern man, especially, must have stimulating aliments which furnish him with the most active and most digestible plastic matter in the smallest volume. A

mixed diet of meat and vegetables seems to agree with him from every point of view.

It would be wrong, however, to suppose that privation of muscular tissue prejudices his physical energy ; but heredity and custom play a large part in this matter.[1]

According to J. Sinclair, the Hindoo pattamars, carriers of despatches, who only eat rice, run every day, passing from one town to another, twenty leagues at least, and continue thus for weeks. Russian agriculturists who live on vegetables, black bread, milk and garlic, work sixteen to eighteen hours per day, and their strength is said often to exceed that of the American sailors (Bremner and Howland). The Norwegian peasants scarcely know of animal alimentation ; they cover, however, whilst accompanying the carriages of tourists, from three to four leagues, running without stopping. Modern Egyptian workmen and boatmen, who from time immemorial have fed almost exclusively on melons, onions, broad beans, lentils, dates and maize have remarkable muscular strength (Lane and Catherwood). The miners of South America, very sober workmen, who do not eat meat, carry on their shoulders weights of 200 pounds, with which they mount twelve times a day, on an average, vertical ladders 60 to 80 metres high (F. Head, L. Playfair and Darwin). According to H. Ranke, the woodcutters of Upper Bavaria feed almost exclusively on flour (1,100 to 1,200 grms. per day) cooked with hogs' lard (90 grms.) without eggs or cheese ; on Sundays only they have a little pork. They do, however, an enormous amount of work.[2] The Turkish soldier is extraordinarily abstemious; he only drinks water or lemonade, feeds on pillaff of rice and figs and scarcely touches meat. We know that his vigour is remarkable and his courage indomitable. The street porters of Salonica and Constantinople, who are fed in the same way, are of a proverbial strength. Hence the saying : *As strong as a Turk.*

I add that I have known very intelligent people, men and women, who, having become vegetarians from principle or for hygienic reasons after having formerly eaten flesh like every one else, have told me that they have done admirably with absolute abstinence from the point of view of their strength and of their health.

Vegetarianism is then an acceptable, sufficient, and even useful practice in some cases, but we must know its disadvantages as well as its advantages.

Its advantages are those which result from temperance : by this method of alimentation the tendency to arthritic, gouty

[1] We extract the majority of the following facts from the interesting work of Mrs. A. Kingsford (Thèses de Paris, 1880).

[2] *Zeitsch. f. Biolog.*, Bd. XIII, p. 130.

or rheumatic diathesis, to neurasthenia, etc., disappears or is weakened ; the character becomes supple and the mind seems to enjoy more rest and perhaps acuteness.

I have shown (p. 376) what the influence of meat food is on the character of animals. As to the action of a vegetarian diet on the intelligence, here is the opinion of two celebrated men who were keen observers of themselves.

Writing to his friend Firmus, who gave up the Pythagorean doctrine to eat meat, the philosopher Porphyre[1] says :—

" It is not amongst the eaters of simple and vegetable foods, but amongst the eaters of flesh that assassins, tyrants and thieves are met with. . . . I cannot believe that your change of diet is due to reasons of health, for you yourself have constantly affirmed that vegetable diet is much more suitable than any other, *not only to give perfect health but even a philosophic and balanced judgment, as a long experience had taught you.*"

And Seneca, who, preoccupied with the same considerations, had slowly adopted vegetarianism, writes (*Epistol.*, 108) : " Struck by such arguments, I also have given up the use of the flesh of animals, and *at the end of a year* my new habits have become not only easy to me, but delicious ; and *it even seems to me that my intellectual aptitudes have been more and more developed.*"

After having shown the advantages of the vegetarian diet, let us analyse its disadvantages. The results are given in the following remarks :—

Vegetarianism requires *à priori* integrity of functional energy. It is not suitable to constitutions weakened by heredity, illness, age, etc., or to delicate stomachs.

It is recognized to-day that alimentation, in order to allow an adult to produce the heat and mechanical energy which are necessary for him, and to make good his losses in nitrogen, should furnish each day, in our climate, from 80 grms. (in a state of rest) to 140 grms. (when at work) of proteid substances, accompanied by about four times their weight of ternary matters, starches or fats. If one keeps strictly to a vegetarian diet, one can no doubt mix the bread, vegetables and fruits in such a manner as to obtain the normal proportions of the necessary fundamental alimentary principles, but in order to get 100 grms. of albuminoids, a quantity which we shall take as an average amount, it would be necessary (if one wishes to abstain from animal matters), to absorb sometimes immense volumes of vegetable foods. I have made the calculation of this amount, for some of them, in the following table :—

[1] Porphyre, really named Malk, born at Tyre in 233, A.D., taught philosophy at Rome, where he died in 304. He published a life of Pythagoras.

Foods.	Albuminoids.	Starchy Matters and Fats.	Weight of Fresh Foods containing 100 grms. of Albuminoids.
	grms.	grms.	grms.
Bread	100	562	1,205
Potatoes . . .	100	1,536	7,690
Beans	100	245	424
Haricots . . .	100	240	512
Peas	100	279	454
Salad	100	170	7,142
Apples	100	1,750	25,000
Cherries	100	2,140	14,300
Chestnuts . . .	100	617	1,661

Thus 1,205 grms. of bread, 7,690 grms. of potatoes, 424 grms of beans, 1,661 grms. of chestnuts, 7 kgs. of salad, 25 kgs. of apples would be necessary to furnish us each with the requisite quantity of 100 grms. of albuminoids. It is true that the excellent alimentary association of 603 grms. of bread and 222 grms. of beans would procure us 100 grms. of albumin and 403 grms. of ternary substances for a total weight of 815 grms. only of fresh foods. In the same way, 1 kg. of potatoes and 450 grms. of haricots would bring 100 grms. of albuminoids and 395 grms. of ternary substances. A similar mixture of bread or pap made of flour of beans, lentils, dwarf peas, etc., constituted indeed the rational and almost sole food of the peoples of ancient Italy, the *pulmentum* of the old Latins. Even at the present time it is sufficient for some classes of workmen. The agricultural populations of Siebenbürgen (Germany) are fed thus, even during the very fatiguing time of harvest.[1] The pap of maize is sufficient almost by itself for the Lombardy peasant and for the poor populations of the South-West districts of France. But, except in cases where excessive work and fatigue suffice to give a relish to the foods, one could not every day return to the same vegetables, even if they were very nourishing. The vegetarian is obliged then to turn his attention, not only to bread and dry vegetables, but to other vegetable foods, fruits, tubercles and herbaceous vegetables, poor nourishments, which could only supply a sufficent amount of albuminoids in an enormous weight, since, in order to obtain 100 grms. of albuminoids, 25 kgs. of apples, 14 kgs. of cherries, 7½ kgs. of potatoes, etc., would be necessary. It follows that, in order to obtain a vegetable alimentation sufficiently nutritive and varied the vegetarian is obliged to have recourse, sooner or later, to exaggerated weights of food ; a method of alimentation all the more fatiguing for the stomach and alimentary canal because it encumbers them with a quantity of useless matters. The herbivorous animal is constructed so

[1] Ohlmuller, *Zeitsch. f. Biolog.*, Bd. XX, p. 393.

as to digest vegetables, but man digests them only very incompletely and more laboriously. We know besides that the albuminoids which have this origin, are not nearly so well utilized by the human intestine as those of animal origin, and for this reason alone it would be necessary to increase these vegetable rations from 15 to 20 per cent.

Efforts have then been made to mitigate the absolute vegetarian diet by the introduction of dishes originating from animals, such as butter, fat, milk, eggs, but at the same time absolutely excluding meat. It is the fasting diet of the Catholic Friday and the orthodox Lent, and that of many monastic orders in all the countries of the Christian, Mussulman or Buddhist world. This alimentation is more rational ; it shares the different advantages of ordinary alimentation and exclusive vegetarianism. The following table shows that this mitigated diet is sufficiently practical :—

Foods.	Albuminoids.	Starchy Matters and Fats.	Weight of Fresh Substances containing 100 grms. of Albumin.
	grms.	grms.	grms.
Bread	100	562	1205
Cow's milk	100	156	1852
Milk and bread (equal weights)	100	431	1528
Eggs	100	90	819
Gruyère cheese	100	86	308
Bread (807 grms) ; cheese (103 grms.)	100	401	910

Thus, equal parts of milk and bread would furnish us very nearly with the quantities of proteid and ternary principles of the normal allowance in the total weight of 1·528 grms. per day. In the same way, 807 grms. of bread and 103 grms. of cheese would bring us for 100 grms. of proteid matter, 401 grms. of ternary matters,[1] very satisfactory proportions in very acceptable weights of nourishment. It would then be quite wrong to accuse mixed vegetarian alimentation of always surcharging the alimentary canal with useless matters. If some aqueous foods, such as fruits, are added, the weight of the food will increase, it is true, but the necessary quantity of drinking water diminishing, the surcharge

[1] Wheat and cheeses in cooked pastes (especially Emmenthaler or Gruyère cheese) can be kept stored for years. Their mixture in the proportion of six parts of wheat to one of cheese forms *in the smallest volume and in normal proportions* the maximum of alimentary principles which can be brought together. We can mix with them dry seed vegetables some of which can be kept from one year to another sufficiently well. We see then that such a victualling, with the necessary salt, represents the *best nutritive reserve for forts and entrenched camps* in case of siege.

will no longer exist. Mixed vegetarian diet can besides be varied sufficiently, thanks to milk, eggs, fatty bodies, cheeses, sugar, wine, etc. It forms a very rational and acceptable diet, and one can, as we shall see, have recourse to it in certain pathological cases, or again when it is a question of softening the character of people individually or collectively, an end towards which our actual customs and the necessities of the present time ill direct us, I grant, but towards which we shall tend sooner or later if only from self-interest properly understood. It is this which vegetarian societies have understood, and pursue, although without too much success as yet. It is objected, it is true, that the vegetarian diet diminishes the physical and moral energy. It is very certain that a meal of meat sustains the strength better than a scanty meal ; but let us make allowance for heredity and custom, and do not let us settle this important question *à priori.* I have already pointed out the physical strength of certain populations or associations which have been deprived of meat for untold ages. As to the energy of character, it is necessary to know how to avoid extremes. Does not the desirable balance lie between the aggressive personality of the race or of the man essentially an eater of meat who goes straight ahead without anything (either law, pity, or sometimes morality) stopping his acts and arousing hesitation, and the passive energy of the Hindoo, an eater of rice, who accepts without question his poor destiny and protects even the life of the dangerous animal itself ? The diet of the one leads him to violence and the abuse of strength ; that of the other to peace-making, but also to passivity. *In medio stat virtus.*

It has been said that the vegetarian diet provokes arteriosclerosis, by reason of the excess of lime which it furnishes ; it has been observed, for example, that this malady is more common in the Orleanais, on a limestone soil, than in Auvergne, where the soil is granitic. But, whilst admitting that this remark is well founded, who does not know that of these two countries it is the second which is the poorest and eats least meat and most vegetables, and how can we attribute to the composition of the soil that which appears to depend on the very different alimentary customs in the two cases ?

Exclusive herbaceous vegetarian diet tends to provoke intestinal catarrh and visceroptosis. It utilizes an important part of the assimilable principles carried off with the intestinal secretions which it exaggerates. According to Rübner, whilst for 100 parts of starch 1·4 only are found again in the fæcal matters if bread serves as the exclusive food, 7·6 are eliminated with potato, 3 to 7 with lentils and 18·2 with carrots, the richest in cellulose of the preceding foods. It is very nearly the same for proteid matters ; out of 100 parts, 20 remain in the fæces if these

matters are drawn from wheat bread, 17·5 if they come from peas, whereas the loss is scarcely 3 to 5 per cent. when they originate from milk or meat. But these figures would change if the food, instead of being swallowed *en bloc* and often badly masticated, were taken in the form of powders or purées, still more if the alimentary canal had received for some centuries a different training.

From these considerations we conclude that absolute vegetarian diet does not answer well to the needs, interest and activity of our European races ; but that mitigated by the addition of milk, cheese, butter, fats and eggs it has great advantages, that it alkalizes the blood, accelerates oxidations, diminishes the nitrogenous losses and toxins ; that it exposes one much less than the ordinary diet (especially if the latter is too rich in meats) to diseases of the skin, arthritism and congestion of the internal organs. This mitigated vegetarian diet tends to make us peaceful and not aggressive and violent beings. It is practical and rational. It should be accepted and commended by those who pursue the ideal of the formation and education of gentle, intelligent, artistic and nevertheless prolific, vigorous and active races.

Milk Diet.

Exclusive milk diet consists of nourishment by milk alone. This food *par excellence* of the newly born answers to such precise needs and renders such evident services that we have naturally been led to try it in many cases that we shall point out later on.

However, milk diet, such as it has often been too radically applied, does not stand critical analysis. In fact, if in a normal state, as we have shown, the adult should receive per day on an average, 100 grms. of albuminoids and 400 to 450 grms. of ternary principles (fats or starches) in order to draw these principles entirely from milk alone, he would need the following quantities of this food, parallel with which I place the quantities of alimentary principles which exist in 3 litres of milk, an amount generally given to an adult when on an exclusive milk diet :—

	1,850 cc. of milk contain	4,750 cc. of milk contain	3 litres of milk contain
Albumin . . .	100 grms. . . .	258 grms. . . .	162 grms.
Ternary materials .	154 „ . . .	400 „ . . .	250 „

To give then 3 litres of milk per day to an adult is to furnish him with a superabundant and useless quantity of albuminoids, and at the same time with far too small, an altogether insufficient quantity of ternary materials, and yet while the weight of these latter is too small, the proportion of fatty bodies is very much exaggerated. If one wished to get from milk alone the necessary quantity of 400 grms. of these ternary substances (fat and sugar), it would be necessary to consume 4,750 cc.

of milk per day, in which case we should introduce into the sys tem the excessive weights of 258 grms. of proteid matters and 170 grms. of fatty bodies, both calculated in the dry state. The logical and well balanced alimentation for an adult *of milk alone* is therefore impossible to attain. For practical purposes we must add to the milk the ternary matters it lacks, such as sugar, fecula and bread, and there is no valid reason, because one has an interest in excluding meat from the alimentation, for taking the arbitrary course of rejecting at the same time the foods which complete and perfect with advantage the good effects of milk diet without the disadvantages of a meat diet or even of a mixed diet.

Milk alimentation, in fact, has for its object and principal effect, whilst sufficiently nourishing the invalid, of reducing to a minimum the extractive and toxic matters which are derived almost entirely from the breaking up of meats : puric bodies, leucomaines, complex amides, extractive nitrogenous matters, etc., so many substances which tend to block up the liver, irritate the nerve centres and fatigue and congest the kidneys. These harmful compounds are derived from meat and not from fecula, sugar or even bread, it is then neither logical nor good, from any point of view, to deprive persons suffering from Bright's disease or disease of the liver of these latter foods.

The addition to the strict milk diet,[1] of herbaceous vegetables, cheese, bread, but without salt, gives the advantage that it is possible to use a much more varied range of foods, and that without introducing the poisonous residues from meat into the system, the constipation which a radical milk diet often tends to produce may be beneficially contended with.

Giving an invalid per day two litres of milk sweetened with 60 grms. per litre and 150 grms. of biscuit or toasted bread, furnishes him with the following quantities of alimentary principles and energy :—

Albumin	90·3 grms.	382 Cals.
Fats	75·2 „	706 „
Carbo-hydrate	270·0 „	1,080 „
		2,168 cals

principles which are normal in quantity and proportions, but the amount of which can be increased proportionally when necessary.

Naturally, the bread and biscuit could be replaced by tapioca, rice, pastes and flour of cereals, the milk be unsweetened and a supplement of casein in powder be added, cooked cheeses allowed, green vegetables, etc. In the place of pure milk the invalid could be given milk slightly and feebly coagulated by rennet, sweetened or not and perfumed. All these foods or alimentary

[1] Provided it is not a question of dysentery or intestinal catarrh.

forms help to digest the milk, to conceal or increase the proportion of albuminoids in the allowance without changing their nature.

We excrete every day, on an average, 10 to 12 grms. of salt by the urine. The preceding alimentation provides us with :—

For 2,000 cc. of milk	1·20 grms.
„ 120 grms. of sugar	0·00 „
„ 150 grms. of ordinary bread . . .	0·12 „
Total	1·32 NaCl

Is it necessary to add to this milk alimentation the chloride of sodium which is lacking in it, that is to say about 7 to 8 grms. of salt per day, if the chlorides already contained in the milk and in the bread are taken into account ?

The experiments of MM. F. Widal and Lemierre and especially of MM. F. Widal and A. Javal[1] show, that in the case of invalids afflicted with parenchymatous or epithelial nephritis, the addition of salt to the milk or ordinary foods increases the urinary albumin and provokes œdema ; and that the subtraction of this salt from the diet, if the latter were composed of bread and meat, causes on the contrary œdema and urinary albumin to disappear ; but they reappear as soon as a sufficient quantity of salt is added to the exclusive milk diet. In the case of people suffering from Bright's disease and œdema, etc., it is especially necessary then, not only not to salt the milk but to avoid, as much as possible, salt entering into their other foods.

It would even appear possible, as has been suggested by MM. F. Widal and A. Javal, to replace milk diet by an ordinary simple régime consisting of meat, bread, etc., but on the express condition that all these foods are prepared without salt.

Experiment has not shown for how long a time an invalid can thus support an alimentation entirely or almost entirely deprived of chlorides.

If in spite of the preceding considerations, an exclusive milk diet is persisted in, it is possible to overcome the repugnance of some invalids by having recourse to sterilized milk which is more digestible ; by adding to ordinary milk, sweetened or not, a spoonful of cognac or kirsch ; by flavouring it with vanilla, lemon or essence of orange flower ; by substituting for one part of milk a similar quantity of an emulsion of sweet almonds. If diarrhœa occurs, the doses should be reduced ; an addition should be made to the milk of rice water, lime or Vichy water, and a little sub-nitrate of bismuth. If, on the contrary, the patient is constipated, barley, a decoction of oatmeal or laxative

[1] *Soc. méd. des hôpitaux*, June 12, 1902, and *Presse médicale*, June 27, 1903, p. 469.

fruits (prunes) should be added. The patient should only return slowly with prudence to an ordinary diet by beginning with purées of vegetables, eggs, cooked cheese, biscuits and bread.

In an absolute milk alimentation the milk should only be taken in very small draughts at a time, and rather slowly.

The application of the milk diet to the treatment of different diseases will be indicated in the following chapters.

Milk taken alone causes loss of flesh from the lack of starchy and sugared principles. By its lactose, salts and water, it acts as a light diuretic. Finally, it possesses an antiseptic action on the intestines. These useful properties explain the reputation of this régime and even its exaggerations.

Meat Diet.

An exclusive meat diet is sometimes accepted through necessity. It has been especially praised by those who think that meat forms the most nourishing and the most fortifying food. In fact, some men obliged to live a very fatiguing life, the trappers and hunters of the pampas of America and the Siberian steppes, the inhabitants of very cold climates, the fishermen living on the banks of the frozen seas, etc., can eat almost exclusively without suffering from it enormous quantities of meat or fish, but on two conditions, that the meat be accompanied with its fat and that the individuals subjected to this diet lead a very active life in the open air. According to Darwin, the gauchos of the American pampas can sustain themselves for whole months on the fat meat of the oxen they watch over. An Esquimaux can devour five to six pounds per day of reindeer or seal's flesh. But this alimentation becomes unbearable if the meat is lean. This has often been acknowledged, especially in England. We have elsewhere given an account of experiments made on animals with an exclusive flesh diet (p. 77) and have shown that for a dog weighing 20 kgs., for example, the enormous allowance of 1,500 grms. per day of lean meat is necessary to keep its weight constant, whereas 400 grms. of meat and 200 grms. of milk, or 100 grms. of meat, 100 grms. of milk and 300 grms. of bread suffice to obtain the same result.

It is the same in the case of man. In order to find the 280 grms. of carbon which are necessary for him each day for the repair of his organs and for the discharge of his functions, 1,600 grms. of meat (without fat) would be essential for an average man. This quantity would introduce as pure waste, four times more nitrogen or albumin than is used. These then are unfavourable conditions from the two-fold point of view of hygiene and economy ; no one besides could consume for any length of time such quantities of meat.

Mixed alimentation, into which meat enters even in a rather

large amount, is that which permits of giving to the system, in the smallest weight, the most stimulating and useful principles ; and it is that which sustains us best, at least granting our actual habits.

But we must not conclude from this that if this alimentation were enriched in meat to the point of becoming one exclusively of flesh, the power of the subjects thus fed would be increased by it: although in carnivorous alimentation the nitrogenous coefficient rises in comparison with vegetable or mixed alimentation, a meat diet acidifies the blood and diminishes the oxidation. It charges the humours of the system with a superabundance of nitrogenous wastes, uric acid in particular ; it increases the urinary alkaloids ; it congests the liver ; it brings an obstinate constipation and causes dyspepsia, gastric difficulties and enteritis ; it leads to psoriasis, eczema, etc. ; it develops rheumatic, arthritic, gouty and nervous tendencies. An alimentation, not even exclusive, but only too rich in meat, could not be endured for long. It produces arterial hypertension and heart fatigue, and becomes one of the most active predisposing causes of arteriosclerosis (Huchard). M. Houssaye has shown that in the case of birds, a carnivorous diet produces sterility, arrest of development and an excessive proportion of males (*C. Rend.* 1903).

Exaggeration in meat diet is then not favourable from any point of view. We have already said that it makes individuals more aggressive, more headstrong, and the intelligence less keen. Do not let us sacrifice to the worship of meat ! The well-to-do classes are only too carnivorous. Herbert Spencer may write very carelessly : " There is a marked contrast between the children of classes where the diet is often animalized, and those of classes where the diet consists of bread and potatoes. From both points of view, that of physical and that of intellectual vivacity, the peasant's child is far inferior to that of the gentleman." [1]

From the point of view of physical health and strength it appears that it is the contrary which is correct ; as to the intellectual vivacity of the child of the well-to-do classes, it is merely the result of heredity, of the selection of progenitors and especially of education.

A diet, the exaggeration of which is the origin of so many physiological and morbid disorders, could not be favourable to the good development of the family or of the race.

[1] H. Spencer, *Education—Intellectual, Physical and Moral*, p. 156.

XXXVIII

ALIMENTARY REGIMEN IN ILLNESS IN GENERAL—DIETS FOR OBESITY—ARTHRITIS—GOUT—GRAVEL

DIET and rest often contribute as much as, and more than, medicinal drugs to restore health to invalids. To help *natura medicatrix*, to return steadily to the normal state and by the most natural means, whilst avoiding as much as possible harmful stimuli, fatigue, the high temperatures of fever and dangerous chills and repairing losses of the organism by an appropriate diet; not to introduce into the system substances either indigestible or in excess, or useless medicines; to give to the invalid foods which correspond to that triple indication of raising the strength, producing the minimum of toxins and making the organs co-operate in ridding themselves of those which arise from abnormal action of the functions, is certainly not to abstain from interference and to abandon the patient to his fate. It is to serve him prudently and as well as possible, it is to avoid troubling unseasonably the complex and delicate internal work whence, as a rule, results the return to health.

What can one do best in the greater number of these severe maladies, eruptive fevers, typhoid, pneumonia, etc.: where we have no specific medical treatment at our disposal and better still, in many chronic illnesses, where the noxious habit of an abnormal alimentation, be it personal, of the family or of the race, often constitutes the most direct cause of the resultant damage, personal or hereditary, from which the patient suffers and the effects which it is necessary to mitigate or banish?

It has been justly said: "*There is no regimen for such and such an illness that is independent of the soil in which the illness is developed.*" It is certain that tuberculosis, syphilis, anæmia, scurvy, diabetes, heart diseases and the greater number of febrile affections may develop in subjects of retarded or accelerated nutrition, of sanguine or lymphatic temperament, and although we are obliged by the didactic exposition of our subject to separate diseases into distinct groups more or less natural, it is very evident that when it is a case of applying dietetic rules to them, one should in every case take into account at once the disease itself and the nature of the soil or *temperament* in which it develops, without forgetting the idiosyncrasies which are often so distinct. It is thus that one has regard to the *individuality* even of the invalid and may hope to act usefully and practically.

This is a very general observation which should be taken into account quite as much when it is a question of feeding invalids as when it is a question of administering drugs to them. It applies in every case.

From a clinical point of view, and also from that of the suitableness of the alimentary diet, it is necessary to separate maladies into *chronic*, which are most often afebrile, and into *acute or febrile*. These last allow of a rather restricted diet, of which more or less complete abstinence from food and the use of aqueous drinks form the principal and common part. In chronic illnesses, on the contrary, the diet should differ with almost each of them, and its composition, even its special details, are often essential. It is then by alimentation during the course of chronic illnesses that we shall commence this statement.

But two other general remarks should find their place here :—

(*a*) The alimentation of the invalid ought to be particularly attended to, his foods of good quality, pleasant to the smell and taste, prepared with condiments which are allowed and sometimes indispensable. The variety of aliments, like their quality and their good preparation, is, as we have seen, one of the conditions of their good digestion and of their assimilation. Already difficult to make acceptable to invalids who have little or no appetite their feeding would become impossible or precarious without this care.

(*b*) In a general way in the feeding of invalids, is it best to be guided by their appetite ? Decidedly it is well in their case to have regard to this feeling of hunger, which is usually a good sign, but it is necessary also to take into account the artificial stimuli which have often created or modified this need. An obese person who consumes succulent and fatty foods, gouty and arthritic persons who eat more than they burn up and eliminate, arteriosclerotic people who feed according to the appetite and drink generous wines, may be compared to alcoholics and to morphia maniacs, who suffer an artificial need of alcohol and morphia. Often born with vicious habits, the invalid's appetite should be controlled by studying the functions and particularly, in the case of chronic invalids, by that of their losses in nitrogen and carbon according to methods which will be explained later. Generally, as has been seen, the man at rest consumes 32 to 38 calories per kilogramme per day ; but 24 to 26 (that is 1,650 calories on an average per twenty-four hours) are almost sufficient for an average invalid in bed. It is possible to make the average calculation of their diet conform to these figures.

Diet in Chronic Illnesses.

From the point of view of their pathogenic relations and

correlatively of the diet which suits them best, we will study alimentation in the course of chronic illnesses, in the following order :—

(*a*) Obesity, arthritis, gravel, gout, arteriosclerosis.

(*b*) Dyspepsia, gastralgia, hyperchlorhydria, hypochlorhydria, dilatation and atony of the stomach, enteritis, dysentery.

(*c*) Congestion of the liver, cirrhosis, diseases of the pancreas, diabetes, azoturia, phosphaturia.

(*d*) Nephritis, affections of the urinary passages.

(*e*) Plethora, hæmorrhages, hæmophylia.

(*f*) Anæmia, chlorosis, affections of the heart and lungs ; dropsy.

(*g*) Cachexias, skin diseases, cancer, rickets, osteo-malacia.

(*h*) Overwork, neurasthenia, madness.

Acid Dyscrasias.

Diseases *through retardation of the nutrition*, to use Ch. Bouchard's expression, are generally of direct or indirect alimentary origin.[1]

They have as a common characteristic a tendency to acidity of the humours and to the production of acid compounds (carbonic, uric, oxalic, etc.). They appear under the most diverse forms according to the organs and tissues where the inequality of the organic imports and exports is slowly, but without discontinuity, produced. Our foods, we know, are specifically assimilated and dissimilated in each kind of organ and cell and the acid dyscrasia may attack the connective or adipose tissues, the aponeuroses, mucous membranes, the different glands, etc., and thus take the most varied forms.

If there is a general cause which, apart from specific individual or hereditary causes, tends *to retard nutrition*, it is certainly the want of sufficient physical exercise. In the case of many men, brain or sedentary work constitutes the only exercise properly so called. The writer, scholar, artist, independent person, the indoor workman, etc., loses, so to speak, little or nothing in muscular force. The human machine tends more and more to be replaced by the steam or electrical machine, and in many respects man only acts as the director of the work which he supervises. His intelligence acts more than his muscles. Formerly distances were traversed by walking or riding ; to-day means of transport of every kind take us from one place to another without our legs performing their functions, without our having to make an inspiration or having a heart throb the more. It is only in the fields that the peasant takes his exercise ; further, agricultural machines are spreading so quickly that the work

[1] These pathological states are sometimes termed diseases through *over-feeding ;* we shall see à propos of obesity or arthritism that it is not always so.

both of labourer and farmer is becoming far less arduous and much more productive. Apparent well being increases from this, food in its turn becomes richer, more abundant, more fleshy, whilst, on the other hand, exercise and with it the organic oxidations and dissimilations diminish. Whence a double convergent current developing and generalizing the maladies essentially alimentary of which we shall speak now.

Obesity.

Obesity is, as it were, one of the forms of arthritis : gout, megrimous and dyspeptic states belong to the same order.

But from the standpoint of regimens it is necessary to distinguish between these different forms of retardation of nutrition.

Fat is the only principle of the organism which is able to undergo enormous variations in our tissues. It oscillates in man between 5 and 24 per cent. of the weight of the body. It is round the heart and kidneys, in the abdominal cavity, and especially in the subcutaneous tissue that it accumulates. It also infiltrates the cells of different organs, of the liver and the muscles, for example, under the form of granulations often nitrogenous. Persons whom fat attacks abnormally become obese. We have given (p. 378 sqq.) the characteristics which permit of defining obesity. In an adult from 20 to 30 years of age, the height being measured in centimetres, if we subtract from it the number 105 the result will be in kilogrammes the weight he should normally have. A subject of 170 centimetres in height will then weigh 65 kgs. Obesity *commences* from the time that this weight exceeds the normal number by more than one-tenth (if it reaches 72 to 73 kgs. in this case).

Fat is produced in the system by the storing up of alimentary fats, but especially by the fatty fermentation of starchy substances and sugars. A very small proportion in a healthy condition originates from the albuminoid bodies (E. Voit; Subbotin).

Is it sufficient to eat moderately in order to see obesity disappear ?

It has been recognized that many obese subjects eat little ; they are obese by constitution, sometimes by heredity. It appears that among them the oxidations, and in general the acts of dissimilation, remain insufficient, perhaps by lack of activity or quantity on the part of the oxidizing ferments. It is known to-day that one of these ferments, and one of the most active, is poured into the blood by the thyroid gland ; another by the testicle and ovary ; another by the white corpuscles.

The want of sufficient exercise joined to an exaggerated alimentation may also cause obesity. A liking for fat foods, starchy or sweetened, suffices to produce it sometimes temporarily.

The following table, borrowed from J. Hirchfeld, shows that with a free alimentation in the leisured class, where there are more obese subjects than in the working class, and among the obese themselves, the consumption of fat or of starchy matters does not often exceed or does not reach that of persons who are not obese :—

QUANTITIES OF ALIMENTARY PRINCIPLE RECEIVED PER DAY.

	Albumin.	Fats.	Carbo-hydrates.	Total of Ternary Compounds.
	grms.	grms.	grms.	grms.
1. Workman (not obese)	98	69	490	559
2. Doctor „ 76 kgs. . .	112	92	340	432
3. Poor woman, 54 kgs.	67	61	344	405
4. Well-to-do woman, 66 kgs. . .	81	74	220	274
5. Obese man weighing 91 kgs. . .	124	112	320	342
6. Obese woman weighing 97 kgs. .	88	82	250	332

According to these figures we see an obese woman (6), weighing 97 kgs., who only takes per day 332 grms. of fats and starchy matters, while the non-obese (3) only weighing 54 kgs. consumes 405 grms. The obese man (5), weighing 91 kgs. consumes 432 grms. per day of ternary foods, like the non-obese doctor, weighing 76 kgs. whose food contains almost the same quantity of proteid principles. The non-obese workman (1) is the one who consumes most ternary matters, but he makes them disappear, oxidizing them rapidly by means of the mechanical work to which he gives himself up.

A sedentary life, the abuse of fat or starchy aliments, the use of beverages too alcoholic or too abundant, the activity or destruction of the genital organs, elevation of temperature of the surroundings lived in, finally and especially a personal predisposition to fatty degeneration of most of the cells—a predisposition often hereditary and akin to arthritis—are the principal causes of obesity.

The real obese appear to be those who, for a normal or supernormal alimentary consumption, burn or consume their fats and nitrogenous matters less than normal individuals. Here are some figures given by A. Robin for children[1] :—

Per kilogramme of weight per 24 hours.	Normal.	Obese.
Quantity of urine	28 cc.	10 cc.
Total urinary extract	1·37 grms.	0·622 grms.
Total nitrogen	0·32 „	0·150 „
Urea	0·261 „	0·270 „
Phosphoric acid	0·067 „	0·022 „
Salt	0·310 „	0·130 „

[1] *Bulletin de thérapeutique*, Paris 1897.

Obese subjects, often megrimous, anæmic from infancy, and sometimes asthmatic, are generally lymphatic and phlegmatic; they suffer from anorexia, their digestions are troublesome; they complain of muscular and cardiac weakness, of nervous troubles, etc. Many eat moderately but all their foods *turn to fat*. Nitrogenous dissimilation may sometimes be exaggerated in them. They cannot remain long without food, albuminoid and fat foods are especially sought after.

There are other obese people, whom we might call false obese or voluntary obese, with whom the pleasures of the table, excess of foods and drinks associated with a lack of exercise and with sleep excessively prolonged, make the receipts exceed expenditure, the ternary matters accumulating in all tissues.[1]

We see that if, in the two cases, it is necessary to excite the oxidations and use up the reserves of fats by means of sufficient exercise, it is in the second especially that it is necessary to diminish the foods, particularly those which introduce fatty principles or those which are changed into fats in the system, namely saccharine and starchy matters. It is necessary to replace them by a little addition of meat. Hence the cure known by the name of Banting or rather of Harvey. That of Ebstein consists of almost entirely suppressing the carbo-hydrate foods (80 to 100 grms. of bread at the most per day) and thus reducing to a minimum the nitrogenous foods, while, however, acting progressively, and especially allowing fats, butter in particular, with the object of weakening the appetite. This is a diet accepted with difficulty by invalids, it makes them anæmic and often provokes dyspepsia.

More efficient and more rational is the practice of A. Robin, founded on the observations of Voit and especially of J. Ranke.[2] Their experiments have proved that if in ordinary alimentation, as much as possible of the ternary compounds are suppressed, not only the fats accumulated in the system would disappear rapidly, but the assimilation of the nitrogenous matters itself diminishes rapidly. M. A. Robin then leaves these invalids to feed themselves almost to the extent which suits them, and four times a day, with eggs, fish, lean meat (this taken cold except at the evening meal). But he is careful to reduce bread to a minimum and all the starchy foods and to suppress almost entirely the fatty bodies. He replaces them by salads, cress, herbaceous vegetables cooked in salt water, and seasoned only with 15 to 20 grms. of fresh butter. Some raw fruits complete these meals.

[1] Ebstein (*Die Fettleibigkeit*, Wiesbaden 1883), allows fats, and their exaggeration even, hoping thus to diminish the appetite of these invalids and because he says the animal and vegetable fats are not those which are deposited in our organs. But these are very debatable reasons.

[2] *Arch. f. Anat. u. Phys.* 1862, p. 345.

Drink, one or two glasses of water slightly coloured red or better weak tea without sugar. To this diet M. A. Robin adds moderate exercise, under the form of walking for thirty or forty minutes after each meal.

This is a very rational treatment for obesity; it corresponds well with the two principal desiderata, satisfying the appetite and preventing the formation of reserves of fat. The need of food is indeed satisfied by the two meals of meat taken as wished twice a day and by the two little intercalary meals which cheat and amuse the stomach. If hunger is aroused, one can, two hours before the evening meal, take a cup of tea without sugar, which is at the same time a heart tonic, and I should see no disadvantage in replacing it by a little light cold broth. But with this diet the appetite is sensibly lessened by the absence of a variety of dishes, the suppression of every condiment (except salt), aromatic bodies, coffee, alcohol, etc., and the repetition of the little meals which occupy the stomach.

Let us calculate by an example, what a diet thus arranged (or one or other of its variations) brings each day to the obese :—

Aliments.		Albumin.	Fats.	Carbo-hydrates.
		grms.	grms.	
Morning, 8 o'clock.	1 egg [1]	7·5	3·6	—
	15 grms. of bread . .	1·2	0·12	7·5
	20 grms. of meat or ham	4·2	0·5	0·08
" 10 o'clock.	2 eggs	15·0	7·2	—
	5 grms. of bread . .	0·4	0·04	2·5
	150 cc. of water mixed with ⅓ of red wine	—	—	10 [2]
" 12 o'clock.	200–250 grms. of lean meat	48	5·5	0·92
	35 grms. of bread . .	3	0·30	18·0
	150 grms. of vegetables	3	1·20	7·0
	150 cc. of water mixed with ⅓ of red wine	—	—	10 [2]
Evening, 4 o'clock.	Tea without sugar .	—	—	—
" 7 o'clock.	250 grms. of meat . .	53	6·2	1·10
	35 grms. of bread . .	3	0·30	18·0
	150 grms. of vegetables	3	1·20	7·0
	20 grms. of butter .	—	18	0·00
		141·3	44·16	82·20

Such a regimen only corresponds to 1,290 Calories per day; and as it is established that in the case of the average adult in a state of relative repose, 2,100 to 2,200 Calories *at least* are

[1] In this regimen we consider it prudent to replace eggs by cheese or milk, as we shall point out farther on.

[2] Counted as sugar corresponding to the alcohol.

necessarily lost by perspiration at the surface of the skin and by direct cooling of the body, it follows that with this diet, 800 to 900 Calories *will have to be compulsorily borrowed by the obese from the combustion of stored up fats*, whence as a consequence *their rapid and forced disappearance.*

Physiological experimentation as well as clinical observations confirm these theoretical conclusions. Dapper,[1] experimenting on himself, demonstrated that with a daily ration of 127 grms. of albumin, 36 grms. of carbo-hydrate matters and 60 grms. of fats (a diet corresponding to 1,350 Calories), he lost 2·7 kgs. in eight days (at the beginning he weighed 93 kgs.) while fixing per day on an average 5·17 grms. of albumin.

For an allowance of 153 to 187 grms. of albumin with a little more fat and a little less of carbo-hydrates, the result was nearly the same. One may then obtain in the case of the obese an emaciation in fat, without there being at the same time loss of proteid materials.

Efforts have been made in the treatment of obesity to largely reduce drinks (Dancel ; Oertel ; Schweninger ; Baelz). These authors do not give any convincing reason for it, although Oertel has affirmed that deprivation of water makes the fats disappear. But the puffiness of certain of these invalids is not due to an increase of water in the tissues. The cellular isotony regulates the water retained in the system and this does not sensibly increase or diminish when more or less is taken. The works of Bischoff, Voit and Schmiedeberg have besides established that water excites oxidations, probably by causing the oxidases to circulate by extracellular osmosis. On the other hand water is necessary to carry off the waste materials and to ensure a regular dissimilation which is rather feeble in the case of these invalids who are often arthritic, gravellous or gouty. Weak tea may agree with them and G. Sée allowed them even coffee. Alkaline waters, especially, appear to give good effects, the blood of the obese being in most cases insufficiently alkalinized.

I only see then in favour of the suppression of liquids, praised by some German doctors, remarks made on great beer drinkers and some observations made on the Japanese by Boelz. But we know that beer fattens not by its water, but by its extract, its dextrins and its alcohol ; as regards the manner of feeding of the Japanese, it differs too much from ours for us to draw any certain conclusions from it.

The meat allowed to the obese may be raw, roast, boiled, salted, but always with as little fat as possible. Lean fish, haddock, sole, pike, gurnet, cod, etc., suit them well. Skimmed milk cheeses may replace a part of the meat. Eggs ought to

[1] *Zeitsch. f. klin. Med.*, t. XXIII, p. 115.

be given only in moderation by reason of the fats of the yolk. They are not besides good for arthritics ; genuine obesity being a form of arthritis it would be better to omit eggs from the diet. An egg can be replaced by 30 grms. of cooked cheese (Gruyère, Dutch, etc.) or by 250 grms. of green vegetables. Seed vegetables, haricots, peas, beans, etc., ought to be especially avoided on account of their richness in starches, fats and nucleins.

I find excessive the absolute exclusion of milk from the diet of the obese because of its butter. Skimmed milk only contains 1·2 to 1·5 per cent. of fatty matters. It has the great advantage of being diuretic and it may be very usefully substituted for a part of the water and of the wine. Half litre of skimmed milk, instead of the 500 grms. of water reddened, would replace in the preceding regimen 20 grms. of sweetened matters (or the corresponding alcohol) by about 6 grms. of fatty matters and 16 grms. of sugar and would only increase the Calories of the diet by 42 units or 3 per cent. This small quantity of milk, at the same time that it excites diuresis, allows without sensible nconvenience of the introduction into the regimen of the obese of a little more variety.

Finally the cure of obesity may be helped by moderate exercise, walking, warm drinks and light purgatives.[1] The Marienbad treatment is thus realized. But it is necessary to remark that exercise increases the appetite ; that if it is prolonged, it tires the heart, already weakened by adipose infiltration, and that it is only slowly and progressively, especially in the case of lymphatic obese persons, that we must try to rid these invalids of their fat ; we must not demand from them either fatiguing exercises or exaggerated abstinence, or repeated purgations which may increase the nervous disorders, weakness or dilatation of the heart.

Warm and lengthy baths at 37° to 38° bring about, it is true, perspiration and diminish the appetite, but their effects, in the cure of obesity, are very inconstant.

The study of the therapeutic action of thyroidine, which strongly accelerates oxidations, as we know, and produces a rapid emaciation, does not come within our province. It is a medicine and not a diet. I would say, nevertheless, that this practice seems to me ill-timed especially because it often produces cardiac troubles in patients whose heart is fat and already weakened : because we have seen these troubles prolonged even after the treatment has ceased ; also because a glycosuria, temporary or not, may be the consequence of this very active treat-

[1] The grape cure consisting of eating from 2 to 5 kgs. of this fruit per day acts as a laxative. But its effects are inconstant and doubtful.

ment; because finally for its uncertain action, the more sure and less dangerous dietetic means may be substituted which we have noted and discussed earlier.

A good treatment of obesity ought to diminish the weight of the body, the first week, by 2 kgs. of which 800 grms. to 1,200 grms. are lost at the expense of the fats and 800 to 200 grms. by the muscles, according as the patient is more or less fat. The loss of weight falls afterwards to 100 or 150 grms. per day, about a quarter of which corresponds to the diminution of weight of flesh itself.

Arthritis, Gout, Uric and Oxalic Gravel.

These maladies are characterized by the accumulation in the cutaneous tissue, articulations and humours and in the different organs, of urates or of oxalates, the deposit of which produces painful sensations, direct or reflex.

No more than for the obese can it be stated as an absolute rule that arthritics, persons afflicted with gravel and gout always eat too much; but it is certain that the greater number eat beyond the limit of strict necessity and especially beyond the power which they have of destroying and burning the excess of the foods which they receive.

Organic hyperacidity being the rule in the case of arthritics, the necessity of alkalines and particularly of the foods which alkalinize the blood is understood. Hence the restriction of all acid dishes, exclusive of vinegar, lemons and ripe fruits. But in the case of gouty people the excess of uric acid in the urine is far from being the rule. Only a trace of it is found in the blood outside of the attacks. On the other hand, in the coming on of gout, this acid may rise, according to Garrod, to 0·17 grm. and more per litre of blood. An interesting fact is that at this moment this acid diminishes in the urine until the end of the paroxysm, to be then abundantly secreted by the kidneys.

In his lessons on *Nutrition retardante*, M. Ch. Bouchard advises persons threatened with gout warm baths, cold lotions with energetic friction, exercise, gymnastics, moderation in the use of meat, and the daily addition to the diet of herbaceous foods which temper the acidity arising from the meat and ensure better assimilation of the proteid substances. Garrod had already observed that vegetable alimentation substitutes hippuric and benzoic acids for uric acid. We do not yet know in the case of a gouty subject if this last acid is always produced more abundantly or if it is only deposited with more facility for an unknown reason which hinders its solubility. In these invalids, the blood does not appear to be perceptibly more acid than in the normal state.

For the gouty, neither generous wines, beer, liqueurs, coffee, chocolate nor spices are allowed. Not too much bread, little meat, and a great deal of green vegetables, few fatty bodies which the subject ill consumes and which impede nitrogenous dissimilation. No highly seasoned dishes, or foods which produce uric acid in abundance or which determine its formation by checking oxidations. Garrod, however, allows these invalids to drink cider provided it is not too acid. A plentiful supply of aqueous drinks (Contrexeville, Vittel, Evian, Wilbad waters) hot rather than cold, mixed with a very little light wine; alkaline waters taken in moderation or diluted solutions of bicarbonate of potassium to the extent of 4 grms. per litre or citrate of lithium (50 to 70 centigrms. per twenty-four hours).

It is especially important in the case of persons predisposed to gout to avoid a sedentary life in too hot surroundings.

Ch. Bouchard has excellently summed up the principal causes of arthritis and gout. "The uric acid increases by good fare, by too copious meals, by the abuse of nitrogenous foods, by acid dyspepsia, by drinks too insufficient, gaseous, acid and sweetened, by champagne and cider, by insufficient or exaggerated muscular exercise, by insufficient cutaneous activity, by cold, by a sedentary life, by habitual residence in confined air, by nervous atony, by sadness, by hypochondria."

Let us give here a few precise directions on the different foods allowed or forbidden to these invalids.

Those which furnish the maximum of uric acids are meats and especially those of very young animals (veal, pigeon, chicken) and the gelatinous parts (head, feet, skin). Smoked meats, dishes very rich in nucleins (sweetbread, brains, eggs and bread itself); jellies and gelatins provoke at the same time the formation of uric acid and of oxalic acid. Arthritics should abstain as much as possible from foods rich in free or combined oxalic acid (sorrel, spinach, etc.) without it being possible, however, to say that the tendency of these foods to produce uric acid is in proportion to the quantity of oxalic acid which they contain.

Arthritics and gouty people should only take soup or extract of meat in great moderation. As much as possible they should take their meat boiled.

Eggs are unsuitable for many arthritics although they only produce very little uric acid: they cannot be absolutely forbidden them.

Arthritics ought to avoid foods too rich in fats, and sweetmeats.

Milk is excellent for them; it is diuretic; it does not increase the uric acid; it supplies the deficiency of meat.

Ordinary coffee should be replaced by that mixed with chicory.

It is necessary to beware of too succulent dishes which excite the taste and appetite ; it is necessary to give up all spiced condiments except salt, vinegar and lemon.

All green vegetables very rich in water may be recommended to these invalids ; but they must abstain from incompletely developed vegetables, or those rich in oxalic acid : green haricots in the pod, sorrel, spinach, stick rhubarb. Chocolate and cocoa should especially be avoided, although their noxious action is not in proportion to their oxalic acid. *The tomato is wrongly forbidden to them* when it is well digested by the stomach. This fruit only contains a slight trace of oxalates, and its malates and acid citrates alkalinize the blood. Besides I can state from experience that on the contrary it possesses no disadvantages for arthritics. Moderate use of asparagus does not appear to have been proved as being harmful, although this vegetable has often been forbidden.

The use of cooked, and especially raw onion, appears to be suitable to the gouty. It is known besides that this food is a stimulant of the functions of the skin and that respiratory activity increases with the cutaneous activity.

Light non-acid wines, cider itself, small beer, weak tea in exciting the renal secretion, will be useful, provided that they are taken in great moderation. But generous wines, strong beer, brandy and liqueurs properly so called, coffee are by no means suitable.

Pure water taken *in abundance* excites the oxidations and dissolves the uric acid (Bischoff, Schmiedeberg.) It is the best drink for arthritic and gouty people. At the same time a *moderate* use may be made of alkaline waters.

Very ripe fruits are excellent for them, as well as the juices and compotes of cooked fruits ; cherries, grapes, plums, oranges, apples, pears, lemons, etc., of which the tartrates, malates, citrates, etc., are transformed in the system into carbonates which alkalinize the humours and dissolve uratic deposits.

With regard to bread, *it is necessary to use it very moderately.* I have shown in speaking of this food (p. 226) that its destruction in the organism sets free an excess of 0·239 grm. of phosphoric acid per 100 grms. of new bread, an acid which does not find any bases which can neutralize it. Bread acidifies the blood by the phosphorus and sulphur of its nucleins and, by them also, enriches too the humours in puric bodies, two conditions which ought to cause the use of it to be formally restrained among these invalids.[1]

[1] A rabbit fed on herbs produces alkaline urine ; it still remains so if the animal is given 30 grms. of sugar per kilogramme per day. If the herb-

Rjasantzeff has proved besides that for an equal quantity of nitrogen introduced, bread produces more acid in the stomach (lactic and other acids) and more nitrogenous urinary wastes than many other foods—three times more than milk for example.

Bread should then be partly replaced by stewed potatoes, which alkalinize the blood instead of acidifying it. I have directly assured myself of the remarkable effects of the partial suppression of bread in the case of these invalids.

Moderate exercise, from half an hour to an hour's walk after the principal meals, regulates the digestion and favours dissimilation. Over-exertion, on the contrary, increases the uric acid.

If the gouty person is cardiac or dyspeptic, the dietetic treatment for such conditions should be applied to him whilst conforming to the preceding rules.

Gravel is one of the complications of arthritis. It may be uric, oxalic or successively assume these two forms in the same invalid.[1]

All that we have said of the diet of the arthritic and of the gouty applies then to an appreciable extent to those suffering from gravel. They should take exercise, keep the stomach free, avoid intestinal fermentations, which always increase oxaluria, guard against disorders of the alimentary canal whatever they may be, of the respiratory and cutaneous apparatus. The subject ought also to refrain from the above-mentioned foods which are too rich in nucleins ; to avoid excess of meat, especially young or gelatinous. Weak tea may be taken once or twice at most per day. The sufferer must be extremely moderate in the use of alcoholic drinks and drink none at table : he should drink abundantly of water. Like all arthritics, the calculous patient should abstain from foods rich in oxalic acid : spinach, sorrel and cocoa most particularly, as well as spices and acid wines.

Here is, according to Esbach, Cipolina and Albahary, the value of the usual foods in oxalic acid :—

aceous vegetables are replaced by seeds of cereals, oats for example, the urine becomes acid and a part of the sugar added to this new diet is transformed into oxalic acid, poisons the animal and kills it. But if at the same time, an addition of carbonate of lime is made to these foods which neutralizes the oxalic acid formed, the urine remains in this case alkaline and the animal does not succumb (Hildebrant, *Bull. Soc. chim.* t. XXX, p. 92).

[1] The adult secretes daily in the normal state from 0·35 grm. to 0·80 grm. of uric acid and 0·002 grm. to 0·015 grm. of oxalic acid ; these figures vary very much from one individual to another, and in the same individual.

Richness in Oxalic Acid of the usual Foods[1] (per kilogramme of Fresh Substance).

	grms.		grms.
Cocoa	3·52 –4·50	Endive	0·02
Chocolate	0·724–0·90	Corn-salad	0·020
(A) Black tea[2]	1·34 –3·75	Cress	traces
Infusion of tea (5 mins.)[4]	2·06	Lettuce	0·00
Pepper	3·25	Radish	traces
Coffee (infusion)	0·13	(C) Cucumber	0·251
Sorrel	2·74 –3·63	(A) Asparagus	0·028–0·044
Spinach	1·91 –3·17	Tomatoes	0·002–0·050
Stick rhubarb	2·47	Carrots	0·030
Green haricots	0·06 –0·21	(C) Chervil	0·035
White haricots	0·31	(C) Dried figs	0·270
Beetroots	0·39	(C) Cherries	0·025
(C) Broad beans	0·280	Currants in bunch	0·13
(C) White bread	0·047–0·130	Prunes	0·12
(C) Crust of bread	0·020–0·130	Plums	0·07
(C) Crumb of bread	0·270	Raspberries	0·06
Brussels sprouts	0·02	Oranges	0·03
Cauliflowers	0·00	Lemons	0·03
Beans	0·16	Cherries	0·025
Potatoes	0·05	Strawberries	0·01
Buckwheat flour	0·17	Apples	0·01
Rye	0·00	Grapes	traces
Lentils	0·00	Red wine	0·00
Green peas	0·00	Pears, apricots, peaches melons	traces
(A) White haricots	0·31		
(A) Dwarf peas	0·425	(C) Milk	0·00
(C) Turnip cabbage	0·311	(C) Liver	0·006–0·011
Green haricots	0·060–0·284	(C) Flesh	traces
Chicory	0·10	(C) Sweet-bread	0·011–0·250

It will be noticed in this table how relatively strong is the proportion of oxalic acid contained in chocolate, coffee, green haricots, which, indeed, greatly favour the production or the deposit of urates and oxalates. The tomato, wrongly proscribed by the greater number of practitioners, scarcely contains, we see, any oxalates *and never produces uric acid in the system, as I myself have proved.* It should be classed with the fruits which may be on the contrary recommended to uratics, if they digest them well.

Stewed potatoes in place of bread, herbaceous vegetables of any kind and pure water should also enter into the diet of those suffering from gravel. Water should be taken by them in abundance at meals. This condition alone when unfulfilled, suffices to cause the appearance of uric acid in the urine, whether because it does not find in the humours the necessary dissolvent

[1] Almost all the figures in this table are from Esbach except those preceded by (C) due to Cipolina and by (A) due to Albahary.

[2] Infused in boiling water for five minutes. Here is stated the amount of oxalic acid which passes with the infusion, calculated for one kilogramme of dry tea

or because the water regulates the action of the organs and especially promotes oxidations. This water may indeed be mixed with a very small quantity of red or white wine or with sweet cider, which make it better supported. These slightly alcoholic drinks help to partially alkalinize the blood and excite diuresis.

Kephir appears to act in the same way.

All strongly flavoured foods, all condiments, all aromatic dishes, liqueurs and brandies should be avoided.

Oxaluria.—When in normal health, the oxalic acid brought by the food is destroyed for the most part in the system ; a small quantity however passes through the kidneys. Oxalates, always in a small proportion (2 to 12 milligrms. per litre), are found in normal urine. They are maintained in a state of half solution owing to the slight acidity of the medium. But oxaluria particularly attacks dyspeptics and still more nervous people and sufferers from hyperchlorhydria. For the rest it may be said that all the conditions which favour the increase of uric acid, contribute also to the formation of oxalic acid at the expense of the albuminoids of the tissues (A. Gautier, Lommel and Lecœur ; Albahary). Meat alimentation in particular and gelatinous dishes still more increase the excretion of these two acids. The influence on this excretion of sugared or fat aliments is as a rule almost nil. But oxaluria especially attacks the obese, gouty and dyspeptic as the following table taken from Kirsch (*Deutsch. med. Woch.*, 1893, p. 673) shows :—

	Oxalic Acid per litre of Urine.	Sugar per litre.
	mgrms.	grms.
1. Obese (50 years)	13·5	38
2. Gouty (56 years)	11·7	1·1
3. Gastric troubles (27 years)	14·5	0·0
4. Obese bon vivant (45 years)	5·4	0·17
6. Grave dyspeptic troubles (40 years)	22·3	33·6
7. Obese (49 years)	12·5	67·6
8. Dyspeptic obese (66 years)	16·3	Traces
9. Nervous dyspeptic (50 years)	10·4	15·9
10. Arthritic obese (57 years)	22·8	6·0
11. Megrainous obese (52 years)	18·0	Albumin
12. Obese, asthma, œdema (52 years)	40·0	Traces sugar
13. Very obese, cardiac asthma, vertigo (45 years)	7·5	,,
14. Obese constipated, dyspeptic nervous (45 years)	53·6	,,
15. Obese, cardiac asthma (62 years)	19·4	1·09

For all these invalids it is well first to avoid all foods rich in oxalic acid, secondly all those which are difficult to digest or which leave putrescible residues in the intestines. The ali-

mentation which suits arthritic, gouty, dyspeptic and diabetic persons, including the partial abstinence from bread, also suits those afflicted with oxaluria. It is necessary again here to have recourse to milk, which greatly modifies the intestinal fermentations and, by its abundant salts of lime, neutralizes the oxalic acid which is formed.

Hyperacidity of the blood results from a too nitrogenous alimentation, from incomplete oxidation in the system of the fats and fecula in excess, from an alimentation too highly spiced and too rich in leguminosæ, from the habitual use of chocolate, tea, coffee, sorrel, etc. Alimentation should be watched then from all these points of view.

In the case of these invalids the slightest indisposition, a chill, a gastro-intestinal disorder, over exercise, night watchings, fatigue, prolonged walking, etc., immediately increase the oxalic acid in the urine. In all illnesses accompanied by dyspnœa, oxaluria would be the rule (Benecke). This remark has however been contested (Fürbringer; Lecœur).

XXXIX

DIET FOR DYSPEPSIA—ABNORMAL STATES OF INTESTINAL FUNCTION

THE term *dyspepsia* may comprise all the troubles of the digestion, which have their seat in the stomach or intestine, whether they be of a nervous, mechanical or chemical order.

Gastric Dyspepsia.—Gastric dyspepsia has given rise to much research. We will not explain it, having here only to treat of regimens. We shall only speak of the pathogeny of dyspepsia, when it can become the source of dietetic indications.

Habitual abuse of food and drink by leading to a continuous overcharge of the stomach, and more particularly a daily excess of meat as well as fecula and fats which delay digestion and cause it to be often accompanied by abnormal fermentations with acid products more or less toxic ; the repeated use of pungent condiments ; that of strong liqueurs and so-called bitters ; the use of bitter wines called tonics (bitters, quinine wine, vermouth and others) ; the custom of drinking pure wine and beer between meals, the abuse of tobacco, coffee, tea ; ice taken habitually whilst eating ; foods taken too hot ; aerated waters ; excess of every kind ; irregularity and too great rapidity in meals, where there is not time to masticate the food ; violent and very fatiguing exercise ; office work immediately on getting up from the table, intellectual overwork, want of sleep ; a sedentary and wearisome life, desk work, etc., are so many causes of dyspepsia. Again I do not speak here of those which are the appanage of a crowd of pathological states, chronic or acute : chlorosis, anæmia, febrile maladies, arthritis, gout, tuberculosis, etc.

From the point of view of treatment and diet, as well as of symptomatology, we shall divide stomachic dyspepsias into *nervous*, *chemical* and *mechanical*.

Nervous dyspepsias (a type which we shall accept, subject to the reservations which we are about to make) are those which only appear to manifest themselves by uneasiness and pain without it being possible, with certainty, to connect them either with feebleness of the mechanical actions, which discharge regularly and periodically the stomach of its chymified products, nor

with the fatigue due to the prolonged repletion of the organ, nor to the apparent disturbances of its function. The secretion, composition and digestive power of the gastric juice are normal, the secretions are not exaggerated; the acidity of the stomachic liquid appears normal or *scarcely diminished;* but the stomach is over-excitable, subject to cramps, painful even between the digestions. These latter are only established slowly; they drag, constipation often ensues and the appetite is irregular.

To this type we shall add stomachic rheumatism, so often unrecognized as such, and the gastric fermentative disorders of A. Robin.[1]

In the case of nearly all these invalids, digestion is slow in establishing itself. At a given time there may be hyperchlorhydria, an abundant secretion of acid gastric juice, but this secretion is slow in arising on contact with foods, a condition which allows these latter, under the influence of their microbes and of those with which the stomach may have already been impregnated, to undergo abnormal fermentation, from whence lactic, butyric acids, etc., result, as well as the toxins correlatively formed. Hence arises with these invalids a *heavy* sensation, indicative of slowness of digestion, often of gaseous tension and stomachic pain due to the irritation of products which result from wrong fermentations. For those subjects especially who are overworked, neuropaths, suffering from rheumatism, exhausted, morphia maniacs, savants who are overworking the mind, choice light foods are advisable which please the stomach: meat if they like it or can digest it, and sometimes the most unexpected dishes; minced ham, raw or smoked, oysters, boiled or grilled fish from which the skin has been removed, but never fried fish. Those which are too fat, such as eel, salmon, mackerel, fresh herring, etc., should be more especially avoided. Purées, of fresh vegetables (but not those of dry seed vegetables) boiled eggs, cream and broths—not too hot—thin herb soups, fresh butter, well baked bread, but in small quantity, ripe fruits, etc., generally suit these invalids. It is especially necessary that they should feed very moderately: 1 grm. of albumin at the most and 5 grms. of ternary matters per kilogramme of their normal weight[2] per day are generally sufficient for them. They should also as much as possible avoid dishes too highly seasoned, too highly spiced or too acid.

As regards drinks, waters slightly alkalized and bicarbonated,

[1] *Les maladies de l'estomac*, Paris 1900, Rueff, publisher, p. 114.

[2] The normal weight, we have seen, is the weight in kilogrammes which corresponds to the figure of the height expressed in centimetres diminished by 100 to 105 according to age; thus an individual of 1·70 m. ought to weigh normally 65 to 70 kgs. If he is dyspeptic he should not receive per day more than 70 grms. of albuminoids and 280 to 300 grms. of ternary matters.

such as de Vals, St. Galmier, Soultzmatt, etc., may be taken; whilst eating, light red wines if there is no hyperchlorhydria (white wines are usually too acid); light beer but in a very small quantity. A little wine often prevents in these sufferers the feeling of heaviness which follows a laborious digestion.

Truffles, mushrooms, pork-butcher's meat, highly seasoned, stews, the juices of roast meat, always too fat or too rich in acid, fats and stimulating aromas should not be taken. Likewise, little or no condiments with the exception of salt and vinegar. It is better still to replace the latter by lemon juice.

Chocolate particularly, concentrated broth, fermented cheeses, sweetmeats and sugared pastries, spices, generous wines, alcohols and liqueurs are absolutely forbidden to these dyspeptic people. They may perhaps digest coffee if they are not arthritic.

All those who eat but little must not be expected to take more than a little exercise, and should sometimes be allowed complete repose. This applies to neurasthenics, chlorotics, anæmics, etc.

The cessation of vicious alimentary habits, which we have already spoken of, and the abstinence from bitter condiments, from so called bitter or tonic beverages, cold and even fresh drinks if there is a rheumatoid condition of the stomach; in many cases a few decigrammes of an insoluble antiseptic (benzonaphtol, iodide of bismuth and cinchonidin for example, mixed with a little bicarbonate of soda) taken at the end of a meal with the object of checking bacterial fermentations and of rendering active the stomachic secretions, the exclusive use, if necessary, of hot drinks, will be sufficient to cause many of these so-called nervous dyspepsias to disappear.

This, however, as we have already stated, is a somewhat theoretical standard, for there is no digestive trouble which is not accompanied by a modification of stomachic and even intestinal secretions.

From the standpoint of the natural agent which best favours at once digestion and stomachic antisepsia, that is to say hydrochloric acid, *chemical dyspepsias* may be divided into *hypochlorhydria* and *hyperchlorhydria*.[1]

Generally, stomachic hypersthenia is maintained by an excessive secretion of hydrochloric acid which arrives at its highest point three to four hours after the meal, especially during the night, and which may even be continued when the stomach is empty or nearly empty of food. At a certain time it manifests itself in persons suffering from pyrosis by a sharp pain in the epigastric

[1] Pavlow, *Die Arbeit der Verdauungsdrüsen*, Wiesbaden 1898. Von S. Ohlern, *Berl. klin. Woch.*, 1891, pp. 491, 517; Bachmann, *Arch. f. Verdauungskrankheiten*, 1899, p. 336; Linossier and Lemoine, Valeur chimique du chimisme stomacal, *C. Rend.*, Congrès français méd. intern. Lyon, 1894.

hollow, exaggerated salivation, sometimes eructations, burning regurgitations of excessive acidity ; there may even be vomitings. All these troubles abate for a few hours at least with a glass of water, especially alkaline water, a little bicarbonate of soda, a cachet containing some decigrammes of a mixture of chalk and magnesia. An addition of 5 to 10 milligrammes of opium per cachet may be made. These attacks occur after each meal, especially in the evening ; they cause the patient to develop continuous acid stomachic secretion, chronic gastritis and ulceration of the organ. In serious cases of hyperchlorhydria after fasting seven or eight hours, 1 litre of gastric juice, very rich in hydrochloric acid, may be found in the stomach.

Setting aside the therapeutics which we have not to consider in this work, what is the suitable regimen for these sufferers ?

As regards quantity, they should be very moderately fed and generally should not exceed 1·2 grms. of alimentary proteids per kilogramme of their weight.

Concerning the nature of the foods the question has been studied and answered in different ways by the following authors : Boas, Penzoldt, Einhorn, Ewald, etc., who recommend sufferers from hyperchlorhydria to eat raw or underdone meat because it is the most easily digested food ; Dujardin-Beaumetz, Rosenheim, Flexner, Moritz, Bachmann, etc., on the contrary, starting from more theoretical considerations, prefer a vegetable and starchy alimentation which stimulates much less the gastric secretions. But if meat produces a secretion of hydrochloric acid nearly twice as abundant as rice, for example, or other analogous vegetables, it also possesses the advantage of most completely neutralizing this acid, in such a way that after a meat meal, the acidity in total HCl only exceeds, on an average, by 22 per cent. that of the stomachic contents after an exclusively vegetable repast.

From the standpoint of the production of the total hydrochloric acid formed in the stomach, the increasing order is as follows : Milk, bread, potatoes, flours, eggs, roast meat (Bachmann). Milk is then the food which has the least excito-secretory action on the stomachic glands ; it is also that which best neutralizes their free *hydrochloric acidity*. Milk is then the food which appears here also to be the most favourable. But in order to support it well, it is necessary to take it every three hours, a quarter of a litre at the most, and in very small draughts at a time every two or three minutes. Two to two and a half litres are sufficient if the invalid is to be put on an absolute milk diet.

But more often sufferers, from hyperchlorhydria may be allowed scraped raw meat, boiled brains, lean fish, boiled, and milk foods with or without eggs. Milk itself may be taken pure or sweetened, hot or cold, mixed or not with water or decoctions

of fruits, apples, pears, etc. ; mixed with lime water, sub-nitrate of bismuth, a few drops of laudanum if the patient has diarrhœa ; and a little calcined magnesia in the opposite case. Milk deprived of butter, or skimmed, is usually preferable in these different cases. This skimmed milk still contains all its natural nitrogenous plastic elements.

The quantities of milk allowed to patients should be very moderate and in every case remain within the limits of digestibility. At the beginning, 1½ to 2 litres of milk per day are generally sufficient. We shall recollect that 1 litre of milk sweetened with 60 or 80 grms. of sugar per litre, is equal to about 1,000 Calories. Invalids undergoing this regimen should then only take a little exercise and live in warm and temperate surroundings. If milk provokes acid regurgitations, we may combat them with powders of carbonate of lime and magnesia, this latter in a variable quantity according to the case. A little coffee and some biscuits may be added to the milk.

There is nothing to prevent eggs, meat and vegetables also being taken, but the milk should always predominate. In fact meat accustoms the stomach by degrees to hydrochloric hypersecretion, which is often only the consequence of an abuse of carnivorous diet.

Let us add that Ewald and Boas having proved that oils and alimentary fats greatly modify the acidity and the secretions of the stomach, it is natural to add oil, butter and cream, to the food of these invalids.

When the acute stage has disappeared, the patient may pass little by little to boiled eggs, non-fermented cheeses, boiled fish —avoiding those which are too fat (see earlier) ; then he may be allowed to return to meat, especially raw or slightly smoked mutton, beef or lamb ; then roast meat, hashed and well masticated, cooked and slightly salted ham. Finally seed vegetables (peas, beans, lentils, etc.) in purée may be tried, but with prudence.

These foods will aid the patients to fight against the acidity of the humours which the return to the too nitrogenous diet, which has most often provoked these troubles, would bring about. Cabbage, sorrel, dwarf peas, French beans, spinach, rhubarb are forbidden to these invalids. Fruits, especially cooked and quite ripe, are rather to be recommended.

Bread should only be taken by them in a small quantity (150 to 180 grms. per day).

The best drinks are water, pure or mixed with skimmed milk, very light tepid infusions of tea or lime-tree flowers, mineral waters of St. Galmier, Condillac, Alet, Evian.

Complete exclusion, from the regimen of sufferers from hyperchlorhydria, must be made of sauces with melted butter or highly

spiced, fried food, game, pickled meats, fat fish, made cheeses, bitter or too acid condiments, pork-butcher's meat, mushrooms; and especially too feculant foods such as potatoes, haricots, lentils; sweetened dishes, etc., substances which for the most part may rapidly ferment in the stomach and produce lactic or butyric acid. Chocolate and cocoa should also be entirely proscribed. Again, wines and acid ciders should be avoided and only a very moderate amount of beer and other fermented liquors taken. Finally, it is well to give up liqueurs proper and generous wines. In a word, the sufferers from hyperchlorhydria should avoid all stimulants of the stomach and culinary delicacies, all over-eating, and should beware of drinks too hot, or iced and hasty meals.

One often feels inclined to advise for these invalids alkaline waters or powder, with the object of diminishing the acidity of the stomachic juices. But these alkalines should not be taken whilst eating, which would again excite the gastric hypersecretion, but only three hours after the meal. It is better still to replace ordinary bicarbonate of soda by chalk mixed with hydrated magnesia which may be swallowed after having mixed the powder with a little tepid water; whilst never rendering the stomachic contents alkaline, these powders do not indirectly provoke acid secretion.

In the case of sufferers from hyperchlorhydria, the sharp attacks may be made to disappear by washing out the stomach, but it does not prevent their return. I have remarked, on the contrary, that salicylate and especially benzoate of soda in cachets of 0·20 grm. taken from the beginning of the attack, and three hours at least after the commencement of digestion, by substituting for very corrosive hydrochloric acid an acid almost inert and antiseptic, allay the pain and diminish little by little the acid gastric secretions.

Exercise after meals rarely suits these invalids. Most of them after having eaten require an hour's rest at least. They then support fatigue better.

Chemical stomachic atony with hyperchlorhydria is as it were the opposite state and sometimes the ultimate consequence of the preceding: chronic asthenia of the stomach becomes established and is most often noticed in cases of anæmia, chlorosis, lymphatism, scrofula, neurasthenia, during febrile maladies and in advanced chronic illnesses. The painful crisis, pyrosis, heaviness, cramp, burnings, constriction of the stomach, etc., commences in this case with digestion, and no longer, as is the case with sufferers from hyperchlorhydria, three or four hours after the meal. This condition is to a great extent due to false acid fermentations (lactic, butyric and others), which become established at the expense of foods which are digested slowly or badly. Constipation

is the rule amongst these weakened invalids. The acidity of the gastric juice is often only from 0·30 to 1 per 1,000 and rarely exceeds 2 per 1,000 instead of 4 to 5 per 1,000 which it should be normally. It appears that digestion in hyperchlorhydria takes place almost entirely in the intestines.

To these inactive stomachs it is necessary to give only a little food at a time and not to be afraid of the use of antiseptics, for in their case the gastric juice, by reason of its feeble acidity, does not sufficiently impede the bacterial stomachic fermentations.

Besides, antiseptics do not prevent the action of soluble ferments. The best are the most insoluble; benzonaphtol (which may be taken indefinitely in doses of 0·10 grm. to 0·20 grm. per meal), iodide of bismuth and cinchonidin of A. Robin (2 to 10 centigrms.), oxide of zinc, etc. We must avoid the benzoates and salicylates at the commencement of the digestion which they stop or render indolent.

Under the influence of chemical considerations, German physicians especially, thought it possible to replace stomachic hydrochloric acid which is deficient in these invalids, by the ingurgitation of a solution in water in the quantity of 1 to 3 or 4 thousandths of this free acid, the digestive action of which is well known.

But it was soon noticed that the acid liquid had the disadvantage of checking the habit of the stomach of secreting its natural acid (Du Mesnil, Jaworski, Linnossier). This practice has therefore been given up and rightly so. Since then, M. Martinet has advised the use, twice a day, of normal phosphoric acid (5 to 10 grms. of a solution of *acid phosphate of soda*, 20 grms. to 200 grms. of water, the whole mixed with pepsin and pancreatin; a teaspoonful each time). I think that the phosphoric acid may be very favourable at the beginning; but it also tends to check the stomach in its secretion of an active gastric juice.

The treatment of these atonic dyspepsias by pepsins, even very active ones, does not appear any more to have given good results.

The following foods are suitable for persons suffering from hypochlorhydria: Raw, roast or slightly smoked meats, beef, chicken, pork, lamb, ham, lean fish boiled in water and sprinkled with a little lemon, milk if it is digested well, eggs in every form, vegetable, farinaceous or meat soups.

The following vegetable foods are allowed: Flours and purées of cereals and potatoes, *tomatoes*, vegetables boiled in water but without pungent spices such as pepper; fresh butter, cream cheese; cooked fruits if they are not acid; rice and dishes very little sweetened; bread, but in moderation.

Strong beers, red wines rather than white, on condition that the patient is accustomed to them and that they are mixed with three to four volumes of water; coffee and tea may also be

taken by these invalids. But these drinks do not appear to sensibly correct stomachic atony. The best are bitter infusions, weak tea and slightly alkaline waters which provoke the hydrochloric secretion.

Fat fish, high meat, pork-butcher's meat, cabbage, horseradish, cucumber, sorrel (but not tomatoes), fried foods, flours of leguminosæ, especially if they are diastasic, for they ferment with great rapidity in these weak stomachs, are forbidden to sufferers from hypochlorhydria. Pungent condiments, highly seasoned sauces and the juice of roast meats should also be avoided.

In order to tone up the stomach it is preferable to replace the condiments by some bitters (a few drops of tincture of nux vomica or ipecacuanha) mixed with a little fluoride of sodium or ammonia, an excellent antiseptic if taken in doses of 1 to 2 centigrms. immediately after meals (A. Robin).

Nothing should be eaten which is not well cooked, well cut up and well masticated. All foods which are too heavy, too herbaceous, too fat and too indigestible should be avoided ; drinks should be neither too hot nor too cold.

It would seem that preparations of peptons ought to agree with these invalids, for, since the stomach is incapable of fabricating them itself, it is logical to supply it with them ready made. However, commercial peptons generally succeed rather badly in these cases : they irritate the stomach and the intestines. This applies especially to peptons of a bitter taste, to somatose and the albumose pepton of Autweiler produced by papaic digestion of meat. Those of Koch or of Kemmerich resulting from the action of overheated water on the flesh of beef, are more agreeable and better supported. The first contains 51 per cent., the second 56·4 per cent. of albumin and extractives. With these the preparations of casein already mentioned (p. 194) may also be cited. But these indolent digestions must not be forced too much ; we must remember that the stomach may be supplemented at need by the intestine, which on the whole may suffice.

Stomachic muscular atony, stenosis of the pylorus due to different causes, especially to the hyperacidity of the gastric juice, and as an ultimate consequence *the dilatation of the stomach*, results in the stagnation of ill-digested products in this organ, and sometimes of hyperacid liquids secreted by the gastric mucous membrane. From the time that the motor function of the stomach becomes weaker, that it is dilated and the chimified juices are not regularly and periodically sent out towards the duodenum through the half-opened pylorus, there is a continuance of the residues of incomplete digestion in the stomachic pouch, overlapping of these digestions, discomfort of the organ, alteration in the stomachic secretions, due especially to the irri-

tation provoked by the remains of the abnormal successive fermentations, etc. Thus it is that these mechanical dyspepsias pass by degrees into the form of nervous or rather chemical dyspepsias.

We have not to determine here the primary causes of the asthenia of the organ, neither have we to describe the ferments and fermentations which thus take possession of weak stomachs (sarcins, bacteria, microbes, saponifiers of fats and producers of fatty acids, hydrogen, sulphuretted hydrogen, carbonic acid, ammonia, etc.). But since abnormal fermentations take place in these stomachs, the first indication is to prevent them. This may be done by two means : 1st, chemical antisepsis (2 to 6 centigrms. of fluoride of ammonia per meal; [A. Robin] 2 to 10 centigrms. of double iodide of bismuth and cinchonidin [do.] ; 0·2 grm. of benzonaphtol, etc.) ; 2nd, mechanical antisepsis : washings out of the stomach, emetics, etc.

These invalids should only be given very slightly fermentable aliments and in forms which permit of their prompt dissolution. The best are : Boiled or roast or light smoked and salted meats, but always taken grated, eggs, sterilized milk, or better still coffee with sterilized milk, preparations of casein and cooked cheeses, lean fish from which the skin has been removed (sole, whiting, brill, turbot, broach, red mullet, etc.), but not fried fish ; fresh butter, green vegetables, fruit well cooked and not much sweetened, toast in a moderate quantity. But all purées and seed vegetables which ferment abnormally in indolent stomachs must be avoided.

The aqueous drinks to be recommended are : Water sterilized by boiling, mineral waters of Alet and Evian, etc. ; weak and hot tea ; infusions of barley or rice with lemon juice added ; light beer, red or white wine, etc., all in a small proportion.

The forbidden dishes are : All foods which are too farinaceous, too saccharine, too fermentable ; cabbage, high meats, game, fried foods, ripe cheeses, fruits containing too much sugar or too much starch, aerated drinks, beer, too acid wines, pure milk and chocolate.

Concerning the condiments we must bear in mind that some are stimulants of the digestion, which they quicken, and that several preparations of mustard in particular, are often well supported and constitute antiseptics of the first order—a valuable property in condiments where secondary stomachic fermentations due to the gastric stagnation of the foods are always to be feared.

Rosenheim recommends his patients, and I think rightly so, to digest as much as possible in a horizontal position, in which case the weight of the foods fatigues the stomach less.

In the grave cases consecutive or not to hyperchlorhydria

where there is a tendency to intestinal ulceration, the following alone may be allowed: Milk, buttermilk, raw meat, thoroughly antiseptic meat powders, eggs, light and not very hot soups, fresh water. At the same time the patient may have a little subnitrate of bismuth to act as a local antiseptic and anti-ulcerative, and in order to diminish the gastric acidity without retarding digestion.

If there is an ulceration with a tendency to hæmorrhage, the patient may be fed on sterilized gelatine mixed with soup or milk (10 to 20 grms. per day); but in such cases the surest way is to have recourse to nutritive injections; we shall revert later to the technique of this mode of alimentation. These injections should be essentially composed of peptons, nearly insipid and as pancreatic as possible. The powder in water mulcifies with a little yolk of egg with the addition finally of a little dextrin (20 grms. per litre), salt (about 7 grms. per litre), and a little strong wine (Malaga, Roussillon, etc., 3 tablespoonfuls). A few drops of laudanum are added to the whole. I have been able thus to feed an invalid in my family for three weeks, without his receiving any food or any drink by the stomach except a little water from melted ice to stop hæmorrhage. The weight of the patient, which was 86 kgs., did not sensibly diminish. He was a very intelligent doctor, then aged 63; ten to twelve minutes after each injection he felt a sort of slight stimulation indicating the absorption of the nutritive substances and of the Malaga. The intestinal ulceration was cured and the hæmorrhage disappeared.

A propos of alimentation by indirect methods, we shall give later the varieties of this mode of nutrition.

When, owing to the complete repose of the stomach, the ulcerative pains are allayed and for several days there has been no tendency to hæmorrhage, the patient may return with prudence to milk, farinaceous paps taken in spoonfuls, purées of green vegetables, milky rice, then to grated raw meat, grated ham, purées of potatoes, bread, etc., but always in small meals repeated every two or three hours.

In *stomachic cancer*, the best foods for the patient are those which leave very little residue, such as milk, raw meat, eggs, etc., all with the use of antiseptics such as benzonaphtol, subnitrate of bismuth, chlorate of soda, and even mustard, which it would be quite wrong to neglect under the pretext that it irritates the sore, which nothing irritates more than its own toxins and the acid products (butyric and lactic) of the stomachic or abnormal fermentations which always occur in such cases.

Acidulated drinks (hydrochloric acid in $\frac{2}{1000}$ths) may be useful to these invalids who often only secrete an intestinal juice bad for digestion and very poor in mineral acid.

Stomachic Giddiness.—Giddiness of stomachic origin can be connected with dyspepsia. It coincides fairly often with hyperchlorhydria, more rarely with hyposthenia of the organ, but it is always, or nearly always, accompanied by secondary fermentations and by the production of harmful or toxic compounds in the stomach.

This giddiness occurs especially when the stomach is empty, two or three hours after meals ; frequently also in the morning when fasting at the moment of rising.

Bretonneau first, then his pupil Trousseau, and finally A. Robin advise, in this condition, the use of bitter tonics (quassia, tincture of nux vomica, etc.), but it is the dietetic treatment especially that they find useful in these nervous troubles.

In the morning for breakfast, boiled eggs, a little bread, cooked fruit. No liquid should be taken at this meal. At the two others, pure or slightly alkaline water may be drunk.

Milky soups or very light meat broths, meat or game, roast or boiled and slowly masticated, vegetables and paste cooked in water with the addition of a little fresh butter, boiled eggs, lean fish boiled without sauce, creams, rice puddings, etc., should be taken. Avoid cooked and fried butter, highly-seasoned sauces and stews, fried foods, pork-butcher's meat, preserves, salads and raw fruits, especially acid ones.

Immediately after the meal, a very hot cup of infused lime-tree flowers, of mint or camomile, should be taken.

After breakfast and dinner, one of the following packets should be swallowed with a little water :—

Calcined magnesia Bicarbonate of soda }	āā 4 grms.
Prepared chalk Lactin }	āā 6 grms.

for twelve packets.[1]

Diet in Pathological Actions of the Intestine.

The pathological conditions of the intestine which are connected with the digestion or which influence it, are : Chronic constipation, chronic or acute diarrhœa, dysentery, typhlitis and appendicitis, cancer. Let us examine the regimens suitable in each of these cases.

Chronic Constipation may result from three causes : 1st, from intestinal atony often maintained by a general morbid state (neurasthenia, chlorosis, tuberculosis, etc.) ; 2nd, from a want of equilibrium in the daily ration between the foods of animal and of vegetable origin, the latter being entirely or partially excluded ; 3rd, from too sedentary habits.

Constipation should be combated by the use of an alimentation

[1] A. Robin, *Bull. gén. de Thérap.*, March 23, 1904, p. 725.

rich in herbaceous and starchy vegetables, by moderate exercise (walking, bicycling, boating, etc.) and by intestinal massage.

We have made known the herbaceous foods in *Part II* and à propos of vegetarian diet we have shown the advantages, and in certain cases the disadvantages, of an abundance of green vegetables in alimentation (pp. 208, 249, 407). The vegetarian diet, whatever its advantages may be, should not be overdone. In cases of constipation, we must add to the animal foods a sufficient quantity (six to seven times their weight) of vegetable foods. The best are: Bread made from pounded wheat, and, better still, from rye or meslin; black bread, vegetable and potato soups; beetroots, cabbages, cauliflowers, salads, asparagus, cooked acid fruits. Mayonnaise and butter are also good. The following act as laxatives: Porridge, bran bread, churned milk, milk-sugar, whey as a drink with or without the addition of tamarind, especially acidulated whey; honey, gingerbread, prunes, lactose (10 to 12 grms.) taken in the morning fasting in lemonade or with a little hot *café au lait* or warm kola, these two last serve to regulate and slightly stimulate the peristaltic movements of the intestine; lastly, aerated waters.

Another good habit is to take, before breakfast, two glasses of cold water, of slightly bicarbonated water, or even of cold milk.

I have not to speak here of medicinal laxatives.

Avoid rice, cocoa, very strong and too generous wines, all fruits rich in tannin, too concentrated meat soups. Some authors think it advisable to abstain from potatoes; I only see reason to the contrary.

The too prolonged stagnation of food in the intestines, especially those of exclusively carnivorous origin, may lead to local inflammation of *stercoral typhlitis* which may involve the ileo-cæcal appendix. Milk with the addition of lactin, kephir, whey, vegetables in light purées, oatmeal, etc., serve to feed these invalids and may help, with the laxatives, to re-establish proper action. But here medicinal intervention should be placed in the front rank.

If *appendicitis* is threatened, the repose of the patient and of the organ by means of opium and almost complete abstention from food are indispensable while the acute condition and nausea persist. The invalids should only be allowed a little milk and water if it is well supported, light vegetable broths with the flour of semolina or rice, milk of almonds and albuminous water. Complete abstinence from foods is necessary while vomitings occur. If these symptoms disappear, if the light foods appear to be supported, one can try then a little veal or chicken broth with semolina or tapioca, some milk gruel, paladas, clear purées of potatoes or of cooked apples, and later a little raw or grated mutton. This alimentation is also the proper one for *peritonitis*.

The stagnation of stercoral matters, the abuse of irritating spices, too stimulating foods, too hearty meals and certain flatulent vegetables may lead to the *hemorrhoidal state* with or without hæmorrhage. In this case, all excess in diet must be suppressed, especially all excess in meat, wine and *highly spiced condiments* (most particularly pepper), whilst salt and vinegar may be taken. For a few days the patient should keep to milk foods, to purées of potatoes, carrots, rice, compotes and very ripe fruits. After, a little boiled fish may be added. He may only return slowly to boiled poultry, ham, fish, light wine and beer. All vegetables which leave too much residue, such as roots, cabbages, haricots, beans, onions, strong coffee, alcohol, etc., should be forbidden. A sedentary life, and especially office life, is bad for these sufferers.

Chronic Diarrhœa or Intestinal Catarrh is often caused or maintained by irrational alimentation. The use of green fruits or of coarse and unsubstantial herbaceous vegetables, black bread or bran bread, salad, dishes too salt or too fat, too acid wine, game and other high meats, raw foods, whatever be their nature if they are badly cooked, indigestible, or too sweet, too starchy, too fat; the use of bad cider and of certain beers whilst eating; bad waters which have not been filtered or boiled, or are too cold. Chill of the feet or stomach may also cause intestinal catarrh. In every case, the best diet consists in suppressing at first, or as soon as possible, all these foods or harmful habits.

The following foods are also advisable in these cases: Albuminous waters[1]; milk when it is well digested and especially sterilized milk, which often produces slight constipation, milk mixed with arrowroot, decoctions of sago, raw grated mutton, mixed or not in soup; later on the lean of grated ham, yolk of eggs boiled or taken with a little lemon. Later patients may be allowed lean fish boiled in salted water, grilled meat, *but only in a small quantity*, purées of vegetables boiled in water previously decalcined by a pinch of carbonate of soda, broths of rice and wheat flour (but not of oats), diastased or not; white of egg cooked or merely beaten up and mixed with drinking water, farinaceous meat soups with bread or different pastes, cooked cheese, cream with egg and milk. Cocoa, quince or currant jelly, preserves of cherries and very ripe red fruits, etc., are suitable for these invalids. As regards drinks, the best in these cases are red wines rich in tannin such as those of Bordeaux

[1] To the white of an egg which has been beaten up to destroy the membranes and then passed through a canvas bag, add 400 cc. of water and a little sugar. If necessary a small quantity of coffee, cognac, Kirschwasser, lemon juice, etc., may be added to this preparation.

or the good wines of the South diluted with water, port, Malaga, tea, rice water, coffee of sweet berries, etc.

But it is necessary to act with prudence whilst feeling our way : only feeding these invalids very moderately at first if one wishes to avoid relapses. Let me recall that in these cases 10 to 15 per cent. of the foods pass into the fæces (instead of 5 per cent. normally), and may irritate the intestines.

The same observations in the case of acute diarrhœa, susceptible to diet and medicinal means.

Muco-Membranous Enteritis is an intestinal catarrh with an abundant elimination of mucus exfoliation of the mucous membranes and intermittent colics. The subjects who are attacked with it, are generally neuropaths and the most suitable diet for them is one which will cause the evil consequences of their alimentary habits to disappear whilst paying attention to their general health.

These invalids should only partake of light meals : four to five per day. In the morning a little milk soup or a broth (with or without yolk of egg) or farinaceous soups (oats excepted), cream of rice, tapioca or sago. This light meal may be repeated at 10 o'clock. At noon macaroni or grated cheese, potatoes with a little fresh butter, brains, lean fish cooked in water, cooked creams, preserves of red fruits. A small quantity of pure water may be taken. In the evening, the same meal as at noon with the addition of a vegetable or meat soup, but light, some purées of vegetable, a fresh boiled egg, cooked fruits, etc.

Rice water to which a little lemon has been added, weak tea as a drink and citronade may be recommended.

In cases of *dysentery*, in view of the hyperemic and ulcerated condition of the great intestine, all cold drinks should be avoided because the reflexes would immediately congest this portion of the intestinal tube. Rice water or barley water rendered acid by the addition of a little lemon juice and slightly sweetened ; toast water, tea, milk of orgeat, may be given as drinks with the exception of Seltzer water, lemonades which are too acid, and coffee.

Boiled milk, or better still, sterilized milk, provided it can be digested, forms a fundamental food for these invalids. Later, additions may be made of decoctions of flour of rice, semolina, powders of casein, and even yolk of egg, grated cheese (Gruyère, Parmesan) and finally the crust of bread and lean minced ham. If milk cannot be digested, raw grated mutton taken in small quantities at a time may be given. Likewise milky meal may be tried. Decoctions of barley, sweet almonds or rice are not so successful. Above all, the large intestine should be washed and disinfected in every portion with large injections (1 to 2 litres containing 0·5 to 1 grm. of nitrate of silver, etc.). One or

two of these injections are generally sufficient and permit afterwards of the digestion of light foods.

The same treatment should be adopted in cases of diarrhœa of tuberculous patients ; here again the most easily supported substances are milk, grated meat, cocoa, red wine, etc. As in the preceding case, medicaments may be added such as opium coated with extracts rich in tannin (rhatany, coffee), which prevent its stomachic absorption, and have a direct effect on the intestine itself.

Gastro-Intestinal Rheumatism.—The stomachic and intestinal walls may be the seat of pains analogous to those which attack the muscular aponeuroses, a pathological condition known as *gastro-intestinal rheumatism.* The principal rheumatoidal state of the intestinal membranes is still little known, but it appears to us to be the origin of a crowd of disorders called nervous, mostly of unknown origin and very difficult to cure. In the case of arthritics it may be brought on by an excess of too cold drinks. In every case, the best way to remedy this condition is to abstain entirely from cold drinks and take only hot aqueous beverages : infusions, weak tea, hot water when needed, even while eating. The patient becomes quickly used to them and the satisfactory effects of this singularly active practice are not long in appearing.

XL

DIET IN DISEASES OF THE LIVER AND PANCREAS—DIABETES, AZOTURIA, PHOSPHATURIA

DIET in Diseases of the Liver.—The function of the liver is to purify the blood and to separate from it, during circulation, the impurities of intestinal origin, to rid the system of the detritus of dissimilation: glycocol, taurin, pigments from the hæmoglobin, amide acids and ammoniacal salts, the ultimate states which the liver transforms into urea, etc. It also hastens the pancreatic digestion and the absorption of fats by the bile which it pours into the intestine.

The liver plays a very important part in assimilation: albumin and peptons, when they are injected into the animal by the vena porta, disappear through the liver and are from that time assimilated; they are, on the contrary, rejected by the kidneys when they are sent into the blood by any other vein, the jugular vein for example (C. Bernard; Ch. Bouchard and Royer; Seegen).

The liver also arrests on its way the alimentary sugar which it changes into glycogen, etc. It elaborates and modifies the intestinal fats. Thus we perceive the very important assimilating function performed by this organ and the necessity of not overburdening its activity by an imprudent alimentation.

Its physiological rôle, its multiple functions of purifying the blood and assimilating the albuminoids and fats, already show at once the way in which one should direct one's alimentation to avoid overworking the liver, or causing it to become permanently congested, or, if it is already out of order, giving it work beyond its power.

Obliged to act immoderately if it receives digestive products which are too abundant, too nitrogenous, too fat or too alcoholic, the liver becomes gorged with blood and hypertrophied owing to the excessive work which these undesirable conditions impose on it; it then becomes tired and weak and sooner or later incompetent. But whether it be in a state of over-activity or incompetency, the best thing to do for this organ, if it is diseased, is to reduce its activity to a minimum, for either it is in a state of hypertension which requires to be mitigated, or else it is in a condition of weakness, of slow or impaired work, and its forces should be husbanded; to attempt to remedy this incapacity by artificial stimulants is to treat it like a cab-horse which is roused to further effort by the whip, it is true, but at the expense of his final resources.

These observations all aid us in dieting those suffering from hepatic ailments. They show that from this latter point of view there is no need to go beyond the classification of these into invalids suffering from hyperstenic and hypostenic livers and invalids with enlarged or contracted livers.[1]

And since this organ is the great transformer of the alimentary chyle and the purifier of the mesenteric venous blood, it is well from the first to take precautions that the alimentation and digestion do not continue to impose work on it beyond its forces.[2]

It is known too that nearly all complaints of the stomach and intestine have an influence on the action of the liver; and reciprocally, the imperfections of nutrition which modify the action of this gland influence the digestive organs.

The diet of the hepatic subject ought then, before all, to spare the stomach, to have regard to digestive troubles, particularly hypochlorhydria which alone suffices to excite and congest the organ.

These subjects then must eat in moderation, restricting thus the work of the liver which, as is known, acts on the fats and sugars but especially on albuminous foods, and particularly on those of animal origin. It is from these foods that intestinal digestion produces the maximum of nitrogenous waste, harmful matters, ammoniacal salts, particularly oxamate and carbamate of ammonia, which the liver is eliminating by means of the bile, with other elements of innutrition if it has not been able to transform them into urea.

It will be understood that it is necessary to impose on hypertrophied or atrophied livers (it makes little difference) the least

[1] As signs of hepatic incapacity, M. A. Robin indicates the following (*Bull. thérapeutique*, March 23, 1904; p. 168):—

1st. The presence of *urocrythrin* in the urine. It is the pink pigment which reddens the slightly acid urines of certain invalids, as well as the deposits which form there.

2nd. The lowering of the nitrogenous coefficient $\frac{\text{urea nitrogen}}{\text{total nitrogen}}$ This coefficient becomes in these cases lower than 0·80.

3rd. The lowering of the proportion of $\frac{\text{mineral sulphur}}{\text{total sulphur}}$ or the coefficient of the oxidation of the sulphur.

4th. The more or less great discoloration of the excrements.

5th. The diminution of the reactions of the liver submitted to the action of the cholagogues.

I add that in the case where the liver acts imperfectly, the toxicity of the urine rises above the normal, and the phosphotungstic or silicotungstic reactions indicate in the renal excretion the relatively abundant presence of nitrogenous matters of alkaloid nature.

[2] See, on the subject of *Diet of Hepatics, Bulletin de la Société de thérapeutique*, Report of M. Linossier, Meeting, January 27, 1904 and discussions. Meetings of February 24, and March 23, works and discussions from which we have borrowed several of the views stated here concerning the diet of hepatic subjects.

possible amount of this work of purification, of alimentary transformation or selection.

Thus, those suffering from disorders of the liver of whatever kind they may be, should avoid an alimentation which is too abundant or too nitrogenous. The latter, moreover, while provoking hydrochloric hypersecretion influences the liver on the one hand by irritating on its way the ampulla of Vater and on the other hand by bringing the nitrogenous matters of anomalous fermentations, gastric or intestinal, which provoke and augment the purifying work of the gland.

It is well also to avoid the abuse of foods which are too succulent and too fat, spices and everything which may produce hyperchlorhydria (p. 436).

The same remarks apply *à fortiori* if there is jaundice with gravel or biliary calculi.

Meats which are too young, and particularly veal, or too much charged with extract (venison, over-worked animals, high or pickled meats, crustacea, fat or preserved fish) are especially to be feared. But as albuminoids are above all necessary, it is especially from a vegetable regimen and milk that we should obtain them without, however, absolutely excluding meat, except perhaps in cases of atrophic cirrhosis and other serious conditions of the liver, where a lacto-vegetarian diet should be exclusively adopted. We know that Nencki and Pavlow have proved that when, in the case of a dog, by means of an operation for fistula known as Eck's, the portal vein is directly brought into the inferior vena cava, thus suppressing the hepatic portal circulation, it is possible to feed this animal almost indefinitely on milk, vegetables and bread. But from the time it is given meat, the dog becomes surly and snappy, is seized with grave nervous disorders and ends by dying. Nencki established that, in this case, the liver no longer eliminates the poisons which form themselves, particularly the carbamate of ammonia, which is found again in the blood and which, henceforth, reacting by its toxicity on the nerve centres, produces the disorders noticed.

It is true that milk introduces into the organism a superabundance of fatty bodies which should be avoided as much as possible. But we may give skimmed milk, which does not contain more than 10 to 15 grms. of butter per litre and which has lost none of its albuminoids.

M. A. Robin considers the milk diet as rigorously necessary in cases of hypertrophic cirrhosis, the congestive period which precedes the state of atrophic cirrhosis, and in cases of patients with the big liver of Reichmann's disease, with gastric ectasia. M. Mathieu also recommends the lacto-vegetarian diet in all these cases, but most particularly in cirrhosis and in amniocholitis (*Bull. thérap.*, *Séance* of March 9, 1904.

All fatty foods and consequently also farinaceous foods and dry vegetables (potatoes, dry peas, dry haricots, lentils, beans) should be equally restricted because their starchy matters are so easily transformed in the liver itself into fatty substances. It is from this latter point of view and also because of its stimulating action on the digestive and hepatic functions, that it is also necessary to proscribe alcohol and too generous wines, which congest the liver, provoke the formation of fats and prevent their combustion. Further, according to M. Lancereaux, plastered wines would be particularly dangerous and might become the cause of cirrhosis.

These patients must give up coffee and especially chocolate, which are at once too stimulating, too fat and richly oxalic.

They must also avoid all irritating and indigestible vegetables: green cabbage, Brussels sprouts, mushrooms, truffles, turnips, radishes, pickles and gherkins.

Bread should be partly replaced by potatoes, which alkalize the blood instead of rendering it acid.

Spices, especially pepper, have a directly irritating effect on the liver with a tendency to sclerosis (Budd ; Brix).

Dishes too much seasoned with vinegar should be avoided. Lemon may be taken, but in moderation.

Herbaceous vegetables, tubercles and roots, salads, cress, tomatoes and even cauliflowers (but not sorrel and spinach), fresh cheese not too fat, lean fish (sole, whiting, mullet, turbot, haddock, etc.), ripe fruits of every kind, are the foods which are most suitable in these cases. A mistake has been made in forbidding eggs and certain fresh vegetables, such as dwarf peas and French beans, because they contain a little cholesterin. The cholesterin which may be deposited in the biliary vesicle does not originate in this way, the special cholesterins of the foods remaining entirely insoluble and incapable of assimilating in the alimentary canal.

Water and milk diluted with water, very weak tea, and all other harmless infusions are the beverages for these invalids. If there is any hepatic colic, only skimmed milk, cooling draughts and vegetable or farinaceous soups should be allowed.

In *atrophic cirrhosis* of Laennec, the same diet should be followed.

If there is biliary lithiasis, all the preceding prescriptions apply equally and especially to the modified milk diet. It is well in this case to stimulate and regulate the course of the bile by means of a small quantity of roast meat taken at the morning meal, and aided, if required, by watery wine and cholagogues.

In *ailments of the pancreas*, the assimilation of fats is generally badly performed ; they are found undigested in the fæces. They may be replaced by starchy or sugared materials, at least if there is not glycosuria at the same time. In this case, the diet of diabetics is the most suitable.

Diet in Diabetes Mellitus.

Diabetes is an abnormal state of the functions of nutrition, the primary cause of which still escapes us, or at least is very obscure. It consists in an abnormal urinary excretion of glucose with concomitant azoturia which may exceed by 50 to 100 per cent. and more, the normal losses in nitrogen. The principal indication in this ailment is to avoid everything which may excite this azoturia and at the same time this loss of sugar, or its accumulation in the blood.

In the slight forms (*Glycosuria*), the invalid may lose from 10 to 100 grms. of sugar per day with 2,000 to 2,500 cc. of urine. Generally in these cases, he retains his stoutness and the appearances of health. If the carbo-hydrates in his alimentation are almost entirely suppressed, the greater part of the sugar rapidly disappears from the urine. In serious forms of diabetes which very often coincide with the alteration of the pancreas, invalids may lose from 300 to 1,000 grms. and more of sugar daily and pass 3, 4 and up to 10 litres of urine in twenty-four hours. In these cases, whatever is done, the sugar does not disappear from the urine; the invalid has no longer the power for using or destroying what he forms at the expense of his protoplasmic substances. He rapidly becomes thin, undergoing, as it were, a melting of all his tissues and soon succumbs, carried off most often by tuberculosis.

The three principal dietetic indications in diabetes are: 1st, to banish as far as possible every food which may furnish glucose; 2nd, to cure the exaggeration of nitrogenous losses by a suitable animal diet; 3rd, to conform, as much as possible, to the diet which agrees with the pathological state of which the appearance of sugar in the urine is only a symptom.

Hence the following rules: Reduction to a minimum of cane sugar, glucose, ordinary fecula; alimentation in meat proportional to the nitrogenous dissimilation; replacement by fatty bodies of the habitual starchy foods; special diet suitable to the vicious or morbid constitution of the subject.

By reduction to a minimum of the sugar and starches, we mean that the patient should only take the sugar and starchy matters which he can tolerate without the glucose of the blood passing perceptibly into the urine. If, for example, a glycosuric patient taking an average mixed alimentation, loses 50 grms. of sugar by his urine, he should do away with at least 50 grms. of sugar or starch per day, and still more if necessary, until he passes little or no sugar by the kidneys.

We say: Suppression of the saccharose or cane sugar and of glucose, but not of levulose, a special sugar which is not sensibly eliminated; reduction of starchy foods but not of those which Külz has pronounced harmless and which are rich not in ordinary starch, but in inulin and inosit, special starchy saccharine substances

which are unfitted to be changed directly into glucose : such are Jerusalem artichokes, viper's grass, scorzonera, salsify, French beans, chicory, lettuce, cardoons, onions, leeks, many mushrooms, etc.

As to asparagus, radish, cress, long radishes, turnips, horse-radish and especially the vegetables properly so called : spinach, sorrel, cucumber, cole cabbage, cauliflower, sauerkraut, salads of every kind, these may also be taken, as they contain *but very few carbohydrates.* Moreover, cooking carries off from these vegetables a large proportion of their sugars and partly dissolves their starches, which disappear with the water.

Here are some figures which prove this :—

CARBO-HYDRATES FOR 100 PARTS.

	Before Cooking.	After Cooking.
Cauliflowers	3·2	1·4
Spinach	3·0	0·8
Headed-cabbage	5·7	3·2
Asparagus	2·6	1·6
Long radishes	3·1	2·4
Sauerkraut	—	1·2

Thus 100 grms. of cooked asparagus only contain 1·6 grms. of carbo-hydrates, 100 grms. of cauliflowers only 1·4 grms. These foods may consequently be given to people suffering from diabetes.

Fruits properly so called, particularly those of the rosaceæ (peaches, apples, apricots, pears, strawberries, raspberries), containing as a rule only 5 to 6 parts of sugar and 1 to 7 of starch per 100, may, in case of necessity, be tolerated, *provided they are not taken in excess,* as 100 to 150 grms. per day do not introduce more sugar than 10 to 15 grms. of bread do. Moreover half of this sugar is in the form of levulose which rapidly disappears from the blood The same may be said of the orange, lemon, pomegranate, etc.

With still more reason may those fruits, which contain scarcely any sugar or starch, be sanctioned : almonds, nuts, olives. On the other hand, it is necessary to avoid those which are rich in sugar or starch : bananas, chestnuts, cherries, grapes, etc.

Bread with its 45 per cent. of starch is not good for these invalids.

A bread called *gluten* (p. 228) is made for them ; but invalids do not much appreciate it, and these so-called breads contain besides from 8 to 25 per cent., and sometimes more, of ordinary starch.

Breads have also been made from inulin, from almonds (a fruit almost entirely devoid of starch) from aleuronal mixed with flour called *Ebstein bread,*[1] from gluten mixed with vegetable powders,

[1] Prepared with the part of the gluten adhering to the episperma. It contains 8 to 20 per cent. only of carbo-hydrates.

etc. Almost all these preparations contain starch and the invalid very soon tires of them.

It is better to replace bread by potatoes, the use of which has been highly recommended (Mossé). It contains, for equal weight, more than half less starchy principles than bread. If then, 50 grms. of bread were tolerated, they could be replaced with advantage by 100 to 150 grms. of potatoes. M. Mossé has shown that this substitution caused the urinary sugar to diminish and that this food was indeed of all starches that which diabetics tolerated best, at least in average cases, and provided it was not taken in excess.

For ordinary carbo-hydrates we may substitute to a great extent, but not entirely, fatty bodies. This end is practically reached by largely adding butter, bacon, fats, olive oil, to the vegetables which are allowed. Cream from milk well centrifugalized scarcely contains any sugar and is most useful in these cases. As much as 200 grms. of fatty bodies may thus be easily given daily to these invalids. It is not always possible to totally replace the carbo-hydrates, and in order to assure good assimilation it is even desirable that a small quantity of starches should be given to diabetics in the form of bread (50 to 60 grms. per day) or potato (100 grms.).

We have stated that the food of a diabetic should be rich in nitrogen and proportionate to the excess of it which they excrete by the urine.

Without doubt many of these invalids eat too much from habit and should regulate their allowance ; but in the case of thin diabetics especially, consumption becomes rapid even with the poorest and strictest regimen. In these cases, these invalids should be given all the nitrogenous food they can ask for or digest; the same may be said if acetonuria is established.

The animal food of the diabetic may besides be very varied : meats, pork-butcher's meats, hams, game, fish, crustacea (recommended by A. Bouchardat), molluscs, smoked and salted provisions, internal organs with the exception of liver, eggs under their multiple forms (two eggs only per day if there is albuminuria), cheese of every kind, etc.

As to pure milk, it should only be used rarely and moderately and be reserved for those cases where it is indispensable, for example, in albuminuric diabetics, and replaced when possible by cream, kephir and cheese.

For the vegetable part of the regimen, it is advisable to especially use the herbaceous foods already indicated.

Spices and condiments of every kind are necessary to these invalids to facilitate the digestion of the fats. It is the same with coffee and tea. It is permissible, if it is *absolutely* necessary, to sweeten these infusions *very slightly* with a little saccharine or dulcin, although these medicaments quickly fatigue the stomach.

Levulose, erythrite and inosit would be preferable if it were not for their price. Generous wines and even cognac bring a valuable element of calorification. Alcohol facilitates the digestion of the fats and in certain cases diminishes the glycosuria and azoturia. But beer ought only to be allowed very occasionally to diabetics by reason of its dextrin. Cocoa without sugar, which is very poor in starch, may be allowed.

Foods which it is necessary to forbid are: the feculents and flours of cereals and leguminosæ, rice, tapioca, ordinary bread to a greater amount than 80 to 100 grms. per day. In serious cases, where it is necessary to make the invalid absorb large quantities of nitrogenous foods, we may authorize all the vegetables poor in carbo-hydrates which will allow of the digestion and absorption of fat meat. Peas, carrots, beetroots; all sweet fruits, pure milk (in case of need test the susceptibility of the invalid), cane sugar, honey, liqueurs, chocolate, beer, sweetened lemonades are also forbidden.

The beverages to be recommended are: Wine diluted with water, pure water, water with the addition of tea or the juice of a lemon, etc.

I will now give as an example (it may be varied very much) the calculation of a normal diabetic diet. Here is an average patient who loses each day with an ordinary mixed diet proportional to his weight, 42 grms. of total urinary nitrogen, corresponding to 266 grms. of dry albuminoids. This subject weighs 70 kgs. and consumes about 3,000 to 3,200 Calories per twenty-four hours (an average figure for these invalids). The following alimentation will meet perfectly these losses and needs:—

Foods.	Quantities.	Containing: Albuminoids.	Fats.	Carbohydrates.
Beef or mutton (bone not included)	900 grms.	180 grms.	40·8 grms.	3·2 grms.
Gluten bread . . .	70 „	35 „	—	10·3 „
Green vegetables .	300 „	16 „	2·7 „	13·0 „
Potatoes	60 „	0·8 „	0·07 „	12 „
Fish	150 „	23 „	2·1 „	—
Cream	100 „	3·7 „	22·7 „	4·2 „
Butter and fats . .	100 „	1·0 „	85 „	0·7 „
Cheese	60 „	19 „	17 „	—
Wine	500 cc. or 40 „ of alcohol	1 „	—	2 „
		273·5	170·37	45·4
Corresponding Calories:		1,121 Cal.	1,600 Cal.	186 Cal.
For 40 grms. of alcohol (see above) 320 Cals.		—	—	320 „
				506 Cal.

We see that this diet, *which only introduces* 45·4 *grms. of starchy or sugared matters per day* (instead of 380 grms. which is the ordinary rate), nevertheless furnishes to these invalids 3,227 Calories per twenty-four hours, including the quantity of heat attributable to the combustion of 40 grms. of alcohol. This alimentation may be modified besides, by substituting eggs for fish, and even, as we have already said, a part of the potatoes by a little ordinary bread for which diabetics are most anxious.

It is evident (and this observation has often been made already and may apply to all invalids) that the *treatment* of the diabetic patient, and no longer of diabetes, cannot be the same in every case. Hitherto we have only had in view two indications: to prevent the production of sugar, to supply the exaggerated nitrogenous losses. But a gouty, dyspeptic, obese, anæmic, lymphatic, scrofulous or consumptive diabetic subject, a subject who only loses a few grammes of sugar per day and the one whose urine contains hundreds of grammes, and who is threatened with tuberculosis, etc., all these invalids should be very differently fed. In the different cases, in a word, we must satisfy at the same time the indications of the diabetic condition, and also the indication of the disease of which diabetes may only be one of the multiple manifestations.

Azoturia—Phosphaturia.

In polyuria with immoderate loss of nitrogen without there being any sensible amount of sugar in the urine (*Diabetes insipidus*), the state of the invalid no longer requires abstinence from carbohydrates (sugar and starch). In this case again, the diet ought to be rich in nitrogenous matters but without excess of these latter in order not to increase the polyuria too much. The mode of dieting will be fixed by basing it on the preceding considerations and particularly on the quantity of the loss of total urinary nitrogen.

I repeat that salt, coffee in large quantities, glycerine, wine, aromatic foods and medicines, diminish all the nitrogenous secretions.

Phosphaturia with excess of daily elimination of phosphates is produced, more or less temporarily, in invalids suffering from nervous or pulmonary affections, in polyurics, diabetics, persons suffering from chorea and leucocythemia, chlorotics, dyspeptics, in invalids suffering from atrophy of the liver, and finally after an attack of epilepsy. The diet is in each of these cases that which suits these invalids.

Foods which best allow the recuperation of the phosphorus thus lost are meat, fish, crustacea, brains, milts, yolk of egg, sweetbread, bread, and above all, seed vegetables.

Real phosphaturia must not be confused with the deposit of

phosphates which takes place, visibly in the urine, each time it loses its normal acidity, and without the quantity of total phosphoric acid eliminated being thereby modified. This phenomenon is produced in many cases by reason of the want of acidity of the urine (neurasthenia, polyuria, inflammation of the urinary passages, etc.) and without the quantity of the phosphates eliminated in the twenty-four hours being on that account sensibly increased.

Excess of elimination of phosphates by the urine may sometimes be due to the exaggeration of phosphorated alimentation ; that again is not real phosphaturia. Phosphaturia properly so called only exists if the quantity of phosphoric acid reckoned in P^2O^5 exceeds 4 grms. to 4½ grms. per day, or 18 per cent. of the weight of the total nitrogen excreted. There are azoturia and phosphaturia together if, with these exaggerated proportions of phosphoric acid, the average nitrogen eliminated per twenty-four hours exceeds 20 to 22 grms., *the diet remaining otherwise average.*

XLI

DIETS IN CASES OF NEPHRITIS—DISEASES OF THE URINARY PASSAGES—URÆMIA

NEPHRITIS.—In nephritis, caused by renal elimination of certain toxins (cholera, measles, small-pox, diphtheria, scarlatina, typhoid fever, tuberculosis, etc.) or by various poisons (arsenic, phosphorus, cantharidine, lead, mercury, alcohol, etc.), in those which are due to the effect on the kidneys of functional troubles of the skin provoked by colds, burns and various cutaneous diseases, in parenchymatous and interstitial nephritis, the kidney acts as an obstructed filter, which only allows the waste substances arising from the nitrogenous dissimilation to pass with difficulty, and therefore only slowly clears the system of its products of excretion. On the other hand, it may allow a variable proportion of the albumins of the blood to be exsuded. The alimentary proteid matters themselves are able to pass through it, even in the normal state, when they are absorbed in very large proportions, or when the patient is submitted to very violent exercise which congests the organ.

The relative impermeability of the kidney can be measured by the time that it takes to rid the system of methylene blue which the patient has been made to swallow. Again it is recognized by the retardation which waste matters experience in passing into urine, when the proteid materials of the allowance are suddenly augmented or diminished. With regard to this, here is a table borrowed from Hirchfeld :—

	Alimentary Albumin per day.	Daily Elimination.		
		Healthy Kidney.	Diseased Kidney.	
		Nitrogen.	Nitrogen.	Albumin.
1st day . .	70 grms.	10·1 grms.	9·3 grms.	2·6 grms.
2nd „ . .	130 „	14·5 „	11·7 „	—
3rd „ . .	130 „	18·6 „	12·7 „	—
4th „ . .	130 „	19·2 „	14·0 „	3·6 „
5th „ . .	130 „	19·9 „	14·8 „	4·03 „
6th „ . .	70 „	16·2 „	14·2 „	—
7th „ . .	70 „	12·9 „	15·2 „	—
8th „ . .	70 „	10·9 „	14·4 „	—

We see that, according to these figures, the elimination of nitrogen rapidly falls, in the case of a healthy subject, on the sixth day as soon as the alimentary albumin is diminished ; on the other hand, in the case of the diseased kidney, the surcharge of blood maintains, even beyond the eighth day, the excess of nitrogenous renal dissimilation.

The impermeability of the kidney shows itself more completely still if, after the injection or absorption of 8 to 10 grms. of salt, an incomplete elimination of this substance is observed during the following days (Achard, Claude and Mauté) ; but especially if the chloride of sodium only appears twelve to twenty hours afterwards and if its elimination takes several days more.[1]

Chronic nephritis is usually accompanied by albuminuria (0·5 grm. to 3·5 grms. of albumin per day, seldom more). The urine for twenty-four hours is reduced to 800 and sometimes even to 500 cc.

A person suffering from Bright's disease is as a rule dyspeptic ; he suffers from want of appetite and diarrhœa. He utilizes his food badly ; he assimilates it incompletely. He is sometimes azoturic.

From these various remarks we shall conclude that since a diseased kidney cannot, in these different cases, easily purify the blood and tissues of their toxins and other offensive products, it is necessary to reduce the latter to a minimum by diminishing the consumption of the principles from which they originate, at the same time sustaining the patient whose assimilative functions are weakened.

Fish, crustacea, game, sweet-bread of veal, kidneys and especially liver, must then disappear from his alimentation ; also gelatinous dishes, broth and meat juice, fermented cheese, very much salted foods, strong spices, beer, coffee, tea, brandy and, if necessary, wine. Amongst vegetables onions, garlic, radishes, celery, cabbages, asparagus, turnips, truffles and mushrooms will be forbidden.

A milk diet is in these cases well indicated. Since Chrestien and Sémmola, we know that rest and milk are great remedies for chronic nephritis ; skim milk, however, is better supported than pure milk. But the milk diet, in France at least, is applied with exaggerated severity. The digestive troubles that it may provoke, the abundance of liquid which it introduces, the heart fatigue and anæmia that it causes, finalyl, the necessity of building up again the strength of the invalid, who most often eats little and lives at the expense of his own substance, generally oblige us to have recourse to a mixed diet that Von

[1] In these cases it would be preferable to administer bromide or iodide of potassium and to measure the quantities eliminated each day by the urine.

Norden, Senator, Lecorché and Talamon, Hale, White, Polidoro Lucci, etc., have recognized as being more favourable than milk taken alone, at least if the kidneys are still moderately permeable. In this case, cheeses, bread and pastes, soups made from meal, purées of dry vegetables and potatoes, rice, fresh herbaceous vegetables with the exception of asparagus and cabbages, all fruits may be given to these invalids without danger. These foods do not produce, or only in a very small quantity, urinary toxins. The same may be said of well cooked eggs, according to the observations of Oertel,[1] Ewald, Lowenmeyer,[2] Hartmann, and *of meat itself*, which in the average case may be taken *in a small quantity* (100 grms. per day). It is curious to notice, in this respect, that, of all kinds of meat, pork is the best supported by persons suffering from Bright's disease, then beef and lastly veal, high game and fish.

It is also shown in a remarkable work of MM. F. Widal and A. Javal[3] that beef, bread, etc., may enter fairly largely into the diet of those afflicted with Bright's disease, if these foods are *taken without salt*, a condition which suffices to diminish the urinary albumin and to cause the œdema, if it exists, to disappear. According to these last authors, it is in fact more by the small proportion of salt which it introduces than by the nature of the principles themselves of milk, that the milk diet acts in diseases of the kidney.

A person suffering from Bright's disease placed on a milk diet and who did not lose more than 2·5 grms. of urinary albumin per day (instead of 12 grms. as before), had 10 grms. of salt added to the milk : the quantity of urine diminished by 600 cc., œdema reappeared, and the urinary albumin rose to 11 grms. The milk was replaced by 450 grms. of raw meat, 1,000 grms. of potatoes, 100 grms. of sugar, 80 grms. of butter, 2,500 of water or diet-drink, the whole without the addition of salt. Under the action of this diet, the albumin fell to 1 grm., the urine passed from 1,500 cc. to 2,000 cc. and the œdema disappeared.[4]

With regard to this, here are, according to Ch. Richet and Lapicque, the necessary quantities of chlorine contained in our ordinary foods :—

Wine	0·03 grms. per kg.	Dry vegetables	0·60 grms. per kg.
Bread without salt	0·09 „ „ „	Meat	0·60 „ „ „
Fruits and vegetables without salt	0·30 „ „ „	Eggs	1·10 „ „ „
Fecula	0·30 „ „ „	Milk	1·10 „ „ „
		Salted bread, about	2 „ „ „

[1] *Handbuch der allg. Ther. der Kreislaufstörungen*, 1884, p. 108.

[2] *Deuts. Zeitsch. f. klin. Med.*, Bd. X, 3, p. 252.

[3] *Presse Médicale*, June 27, 1903, p. 469.

[4] Does the milk act at the same time by its poorness in chloride and by a kind of specific action ? M. Jaccoud affirms that in the case of people

Our average daily alimentation contains, in the natural state, about 1 grm. of salt, but we add besides 10 to 12 grms. of salt which we may in these cases avoid. MM. Ch. Richet and Toulouse have indicated the following regimens of hypochloridation[1] :—

I. *Foods of the ordinary allowance not salted* ; *contain*		
Chloride of sodium in the natural state, about	1	grm.
500 grms. of non-salted bread . . .	0·14	,,
Total salt	1·14	grms.
II. *Foods of the ordinary allowance* ; NaCl about	1	grm.
Salted bread, 500 grms.	1·20	,,
Total salt	2·20	grms.
III. *Milk diet, 3 litres of milk* ; NaCl about .	3·40	,,
IV. *Diet comprising 3 litres of milk with* 500 *grms. of salted bread* ; NaCl about	6·40	,,

When, in a case of Bright's disease, there is much albumin (more than 3 to 4 grms. per litre) difficult and slow filtration of salt given as a test, subacute attacks of nephritis, œdema, signs of uræmia and consequently difficult renal permeability and danger of eclampsia (in the case of a pregnant woman the least quantity of albumin in the urine accentuates this danger), the doctor should have recourse to an exclusive milk diet. Further, powders of casein may be added to the milk as also fresh cheeses or cheeses *à pâte cuite* but not salted. However, even in the majority of these cases, *it would seem*, according to the observations of MM. Widal and Javal, that one could have recourse again to an ordinary diet provided salt is excluded from it as much as possible. According to them, dechloridation of the foods, that of the plasmas, dehydration of the tissues and the disappearance of œdema, follow the same cycle. Boiled meat without salt, bread without salt, rice, pastry, alimentary non-salted pastes, and sweet fruits would be suitable at this period of Bright's disease.

In order to pass from the milk diet, more or less modified, to the ordinary diet, we should come back again to bread and green vegetables, then to potatoes, eggs, dry vegetables, later on to pork and finally to beef, all the time watching the urine for the reappearance of albumin.

Alcoholic liquors, especially cider and beer, spices and smoked

suffering from Bright's disease submitted to a strict milk diet, the albumin often reappears in the urine during the night, that is to say, in the period of the twenty-four hours in which the milk is withdrawn. The milk would appear, he thinks, to play a specific rôle in checking the albuminuria which would correspond, during sleep, to the dissimilation of the albuminoid tissues of the invalid. (P. Prieur, *Thèses de Paris* 1903.)

[1] *Traitement par la bromuration et l'hypochloruration. Monde Médical*, February 15, 1904.

meats, ought to be forbidden to people afflicted with Bright's disease.

In acute or chronic albuminuria, a diet composed of 2·5 litres of milk, 200 grms. of bread and 50 grms. of Gruyère would furnish :—

	Albumin.	Fats.	Carbo-hydrates.
2,500 cc. milk	70	85	130
200 grms. of bread or 100 grms. of biscuit	20·8	1·7	127
50 grms. of cheese	16·2	14	—
	107·0	100·7	257

This diet would furnish 2,420 Calories per day. It would fatigue the kidney less than if it were necessary to obtain solely from 4 litres of milk the whole of the alimentary principles. It is certain that the exclusive milk diet recommended so often and in such an exaggerated degree, leads to a useless overloading in water and fat of the tissues of the stomach, intestine and kidneys ; a hypertension of the vessels of the heart, and certainly, in many cases, to satiety and repulsion for the invalid.

In cases where milk causes diarrhœa, a little subnitrate of bismuth can be added to it, or one might try almond milk, casein soups, kephir, etc.

In cases of dropsy due to Bright's disease, milk and foods without salt are efficacious. The patient must only be given light meals and his beverages reduced to a minimum ; tea and coffee which provoke diuresis and tone up and accelerate the heart, may be allowed.

Cystitis.—Cystitis may be dealt with by the diet which agrees with nephritics ; milk with the addition of different flours, yolk of egg, vegetable and bread soups, raw or cooked fruits, etc. These invalids should abstain from spices, juices and extracts of meat, beef-tea, alcohol, coffee, wine and beer, and only use foods of animal origin with moderation.

Veal and fish should be forbidden. They irritate the urinary passages and produce eczematous eruptions and oozings which may even sometimes bring blood.

The invalid should dilute as much as possible his urine by drinking abundantly pure or slightly alkaline water (Soultzmatt, Saint Galmier, Seltz), decoctions of barley or the male tops of maize and balsamic drinks. Milk, cream and milk soups, emulsions of almond, yolk of egg and sugar dissolved in hot water, white cheese are also indicated. Fruits (grapes, pears, apples, etc.) cooked or raw, in jelly, etc., are favourable because they alkalize the urine and saturate the acids originating from

the dissimilation of the albuminoids. If there is a tendency to the formation of deposits of urates, of urinary calculi, phosphaturia, oxaluria or gout, the diet should be made to conform with what has been said à propos of these diseases.

Blennorrhagia.—The same mild diet with great diminution of meat, complete abstinence from fish, veal and crustacea, a predominance of milk, exclusion of stimulating dishes, which are highly spiced or too salted, of coffee, spices, wine, and beer is suitable, especially at the commencement of blennorrhagia. Later on, purées made from seed vegetables, herbaceous vegetables, eggs and ham may be substituted for milk. Some vegetable foods : garlic, onions, celery, mustard, radish and asparagus ought to be avoided.

XLII

DIET IN CHRONIC DISEASES OF THE HEART AND VESSELS—PULMONARY DISEASES

Diet in Diseases of the Heart and Vessels

DISEASES of the Heart.—According to M. Huchard, whose authority is so great in all matters concerning disorders of the circulatory organs, in cardiac affections, modifications of the arterial tension play the principal part. According to him, organic cardiac ailments should be divided into valvular and arterial, "the first characterized by their continual and progressive tendency to the lowering of the arterial tension; the second characterized, especially at the beginning, by a contrary tendency to hypertension."[1]

Asystole, tachycardia, weakness of the heart, embryocardia and collapse, are signs of hypertension. It appears to result from the action of the toxins, generally of bacterial origin, on the bulbar centres which control the circulation. These characteristics are met with in typhoid fever, typhus, bronchopneumonia, meningitis, serious eruptive fevers, influenza, tuberculosis, angina pectoris, certain cases of poisoning (trinitrine, an overdose of opium, etc.).

The regimen in these cases will be that which corresponds to these various ailments. Wine or alcohol in sufficient quantity (Stockes), thin soups (Ewald),[2] coffee and caffein (Huchard),[3] tea, chocolate, aromatic condiments, etc., are in these cases particularly useful. It is necessary for the patient to abstain with care from fat and too starchy foods, when the heart is threatened with fatty degeneration, from salted foods if there is œdema. With feeble arterial tension, renal filtration is always badly effected and nitrogenous, particularly animal alimentation,

[1] *Traité des maladies du cœur et des vaisseaux*, 4th edition.

[2] M. Huchard is not much in favour of soup which introduces, he thinks, too many toxins derived from muscular tissue. But I would remark that the soluble parts of meat are only toxic by their excess and are, on the contrary, excellent heart tonics in a small quantity like those found in some cups of soup. If the kidney is healthy, light soup is therefore better to be recommended, as Ewald states.

[3] As medicines, ergot of rye, strychnine, injections of ether.

should be diminished as much as possible, as Huchard has shown. Drinks should be moderate rather than abundant. Injections of artificial serum (water 1,000 grms., salt 8) may be very useful.

It is quite otherwise in ailments with arterial hypertension; sclerosis and hypertrophy of the heart; arterio-sclerosis, arterial cardiopathies of acute rheumatism, of gout and diabetes; myocarditis, aortitis, angina pectoris by alteration of the arteries of the heart or by the action of special toxins, renal or hepatic insufficiency, etc. Here, not only may diet have a great influence on the course of the ailment, but, as Huchard has emphatically established in his important publications, it is to errors of diet, it is in the application of an irrational diet, badly balanced or wrongly utilized by the subject, that most often it is necessary to seek for the effective course which originates troubles of the heart and of the arterial circulation. It is consequently by influencing, from the very first, the diet, that we must endeavour to check the course of the pathological modifications which would slowly and continuously tend towards arterio-sclerosis and myocarditis. "I am convinced," says M. Huchard, "that excess, and especially errors in diet, by throwing into the system a great number of toxic substances, such as the ptomaines not eliminated by the renal filter which has early become insufficient and impermeable, are a frequent cause of arterio-sclerosis. . . . The result is, in the entire arterial system, a state of spasm more or less permanent, which first produces hypertension and following on that, arterio-sclerosis. The conclusion is this: that it is necessary to prescribe a diet from which all foods more or less rich in ptomaines and in extractive matters are excluded."[1]

As the same author has established by 20 years of clinical study,[2] among the determining causes of arterio-sclerosis connected especially with hygiene or dietetics we shall particularly mention: Alcoholism, oversmoking, abuse of spices, which moderate or check the movement of denutrition, excess at table, and particularly an alimentation too rich in meats which acidify the blood, diminish the oxidations, and tend to form deposits of urates, phosphates, etc. All these waste products, all these mineral salts, by diminishing the elasticity of the vessels which they cram up little by little, increase in consequence the fatigue of the heart which is obliged to struggle against these passive resistances.

Intellectual or physical overwork by retarding or moderating the nutrition and dissimilation may act in the same way.

From these different considerations, the question of the diet of these predisposed patients, and especially of patients suffering

[1] Huchard, *loc. cit.*, p. 788.
[2] See *Consultations médicales*, vol. II, J. B. Baillière, publisher.

from cardiac hypertension, resolves itself quite naturally. They must be fed on foods which leave the minimum of nitrogenous wastes, which do not acidify the blood, and which do not encumber either the arteries, kidney or liver. This amounts practically to the *milk diet* (Huchard, Mitchell, Schombert, etc.). But, in speaking of this diet (p. 413), we have shown how it should be rationally supplied. Here especially where it is necessary to combat arterial hypertension it is not an absolute milk diet which suits : it is necessary to qualify it by the addition of sugar, vegetables, cream, preparations of casein, etc., and even of a little meat and, if need be, of a small quantity of cognac, curaçao or rum. The invalid can thus be perfectly fed not with 3 litres, but with 1,800 grms. and less of milk, without enfeebling the heart too much, without increasing the arterial tension which would increase the absorption of large quantities of liquid, and without compelling the kidney to secrete too large a proportion of urine.

Rumpf and Karell have quite wrongly rejected milk diet on the ground that it brings to the coats of the arteries too much lime. This theoretical objection collapses before clinical facts, and before this observation, that lime is furnished to us in an otherwise very important proportion by vegetable aliments, which it is impossible to do without in these cases.

A little meat may be added to the milk, beef or fish *boiled*, and consequently, to a large extent, deprived of their extract; they may be eaten with vegetables and a very little salt. They may be accompanied by a little cooked ham, eggs, fresh or cooked cheese, etc., for it is necessary to sustain the heart, which grows tired. Finally, a part of the albuminoids borrowed from the meat and milk may be replaced by the vegetable proteid materials of seed vegetables. Recourse should be had at the same time to other foods of vegetable origin, with the exception of cabbages, turnips, mushrooms, strawberries and especially celery, of all dishes too aromatic, and of uncooked things.

Again, it is necessary to exclude from the alimentation of these invalids, all food which may over-excite the heart in a state of hypertension : Coffee, tea, chocolate, liqueurs, generous wines, vanilla, cinnamon, spices, food too much salted, extract of meat, thick soups, soups too highly seasoned or too hot, " advanced " cheese, salt provisions, pork-butcher's meat, etc., all that increases the tension of the arteries and in consequence the difficulties and fatigue already experienced by the heart, whose impaired muscular power is forced to make the blood mass circulate through a collection of vessels already contracted or but little elastic. Hence also the need for diminishing the quantities of liquid, and consequently of milk, by modifying, as we have already said, the strict milk diet, and only drinking

what is necessary, choosing particularly diuretic waters (Martigny, Vittel, Contrexéville, Capvern, etc.).

But, when the heart is growing weak, and its strength getting exhausted, and in the periods of asystole and dyspnœa, coffee, tea, wine, brandy and injections of artificial serum are on the contrary indicated.

If there were cardiac œdema, it would be necessary to abstain as much as possible from all salt food.

In great nervous or reflex anginas, meat is rather useful. It is expedient to avoid only too abundant meals, indigestible dishes, too exciting foods, fried fish, fish too fat, vegetables too fibrous or too aromatic, vanilla, coffee, liqueurs, chocolate, salt, etc.

In these cases it is prudent also to take only a frugal meal in the evening.

If, with arterial hypertension there is *plethora*, if the heart is large and hypertrophied, the pulse strong, if there are palpitations, a tendency to cerebral congestions, a full-blooded aspect, signs more or less developed of arterio-sclerosis, etc., it is necessary to have recourse to a considerable reduction of food, especially of nitrogenous food, and to suppress all condiments which excite the appetite and circulation, wine, coffee, spices, etc., in a word, we must follow the most severe regimen previously indicated for cardiac hypertension.

Slight and repeated purgatives are in these cases almost a part of the dietetic treatment.

Arterio-sclerosis.—The invasion of the arterial coats by salts of lime, phosphates, urates, and other residues which little by little encumber the coats to which the vessels owe their natural elasticity and their resistance, constitute a fault of arterial nutrition which is frequently met with amongst the gouty, the arthritic, the rheumatic, the plethoric and drinkers, especially beer drinkers, great eaters, and more particularly great meat eaters, etc. This last observation is enough to prevent our acceptance of the opinion of Karell and Senator who, on account of the excess of lime found in the state of phosphates, urates and carbonates in the arterial coats of these invalids object, as has already been said, to the employment of milk in the treatment of these invalids. Milk and vegetables, foods so rich in lime, do not possess, as is known in cases of gout, muscular rheumatism, arthritis, and in consequence arterio-sclerosis, the harmful influence of meats which only contain very little lime, nor above all the harmful influence of the abuse of too exciting foods which do not contain them, such as coffee, alcohol, generous wines, beer, spices, bitter or aromatic condiments. All that tends to produce in the system puric bodies (uric acid, xanthin, adenin, etc.) on the one hand, and on the other all that may impede the

movement of cellular dissimilation, must, above everything, be avoided. The dietary for arthritics and plethorics is then that which is best suited for these invalids.

Hæmorrhages.—In the course of all hæmorrhage, it is necessary to restrict diet, and to follow the rules previously indicated in cases of arterio-sclerosis and plethora—to avoid above all drinks, soups and foods too hot, all irritant condiments, all excitants of the heart, coffee, tea, aerated waters, abundant aqueous drinks. If there be intestinal hæmorrhage, the patient should be kept to skim milk and very light soups, decoctions of gelatine, rice, barley, and in grave cases recourse should be had to injections of serum and to rectal feeding if necessary, as has been already advised in the case of ulcer.

Chronic Diseases of the Lung—Tuberculosis.

Chronic and apyretic diseases of the lung, like asthma and emphysema, appear little amenable to dietetic treatment. For them, special medical treatment, not to be examined here, is above all necessary. We have nothing precise to say on the subject of the alimentation of these invalids.

The same does not apply to pulmonary tuberculosis, whether it is apyretic or almost apyretic or febrile.

Man is not born tuberculous ; he becomes so when the body is propitious or prepared by general atony, chlorosis, anæmia, overwork, physiological misery, scrofula, dyspepsia, diabetes, etc., to receive and nourish the microbe. It seems then advisable first, to point out here how, by dietary, it is possible for the organism to obtain the maximum of resistance to the development of this disease.

Empiricism has established that nitrogenous and fatty foods, rich in phosphorus, are the most suitable to put the system in a state of defence against Koch's microbe. Among these, the best dietetic means to protect the individual against the invasion of tuberculosis and the destruction of the principal tissues are meat, fish, brains, milk, fat, especially of animal origin (cod liver oil is the best example in the order of medicaments) with exercise in the open air which furthers nutrition.

When the disease is established, food is of more importance than medicine ; therefore we shall not separate here the apyretic tuberculous from the febrile tuberculous. What is necessary before all, is to make these patients take a substantial nourishment which repairs, as much as possible, the losses, often enormous, of nitrogen and carbon, which take place every day by the kidney, skin and lung. Unfortunately dyspepsia has most often prepared the way for the disease and it is only confirmed with it. The appetite rapidly disappears, especially if there is fever ; a

state of chronic stomachic and intestinal atony, generally accompanied by hypochlorhydria, stubborn constipation and later diarrhœa, render all rational alimentation difficult or precarious.

Sometimes when by hygienic care, life in the open air, rest, tannic and iodized medication, and especially the preparations of organic arsenic, the invalid has been toned up, the nutritive functions, especially the intestinal functions, awakened, sleep restored, nocturnal sweats which are so weakening made to disappear, the fever, when existing, partly lowered, then the alimentary treatment may be applied and will assure either a cure or a very long resistance to the malady.

If the tuberculous patient is apyretic, he must feed abundantly, but it must be remembered that these subjects are generally dyspeptic and cannot digest excessive amounts of food.

Sleepiness after meals, heaviness of the stomach, indigestion, diarrhœa, etc., are the signs of overfeeding. Pyrosis, stomachic pains, during the night especially, hot flushings of the face show stomachic hypersthenia or hyperchlorhydria.

For the rest, no matter what has been said, the excess of food, even when well digested, the overloading of the stomach and fattening up, do not cure these invalids. If, after having become much thinner under the influence of medical and dietetic treatment, the tuberculous patient has gradually almost regained the weight which he had before falling ill, we must not go beyond that, nothing will be gained thereby.

In these cases the most valuable foods are : Milk, yolk of eggs and milts, meat, crustacea, fish, bread, seed vegetables, fatty bodies, red wine, cocoa, coffee.

The best milks are those of the mare and ass. The stomach digests these most easily ; cow's milk only comes a long way after. Mare's or ass's milk has a very remarkable influence on nutrition, which it regulates, and on the evolution of the disease, which it checks. It should be taken warmed only in the water bath, and better still directly it comes from the udder, morning and evening, but not while eating or soon after, when the digestion of the previous meal is not yet finished, or else it causes diarrhœa. These milks are much more useful uncooked than cooked ; *they have then a very remarkable effect.* Long after them comes cow's milk ; it may be taken uncooked if the cow is healthy, or cooked under the form of a drink or boiled with rice, flours of barley, rye, wheat, oats, with or without the addition of yolk of egg, sugar, coffee, cocoa, etc. This milk may be mixed with a little brandy, curaçao and vanilla ; or taken sterilized ; to be taken cold if there is any tendency to hæmorrhage. It should be remembered that many stomachs digest milk sterilized but not uncooked ; but heated milk has lost its ferments.

The quantity of milk to be given to the patient depends at the same time on his capability of supporting it, and on the nature and quantity of the other foods. But he ought to take at least 700 to 800 cc. per day.

Certain invalids can only digest milk mixed with cognac (30 to 60 cc. per day) or with good Kirschwasser. This mixture is good for them.

Of the alcoholic derivatives of milk, kephir and koumiss, the first only is nowadays prepared in our large towns. Many people who cannot digest milk can take kephir. It may be taken under the guise of a drink, but it cannot always be given in sufficient quantity on account of its acidity; at least all stomachs cannot get accustomed to it. Nevertheless, nothing would prevent the acidity from being almost entirely neutralized by a little bicarbonate of soda or Vichy water.

Eggs may be given to tuberculous patients under all forms compatible with the tastes of the invalid. It is better, when possible, only to use the yolk; after having separated it from the white without destroying its membranous envelope, it is sprinkled with a little lemon juice, it is salted (or not) very lightly on the surface, and swallowed down at a draught as one would take a large pill, either at breakfast or lunch, etc., and always at the end of a meal. Five to six yolks of fresh eggs may be thus easily taken in the twenty-four hours.

Fish, a food very rich in phosphorus, may be given every day, either grilled or boiled, but not fried. Sea fish especially, cooked in salt water with a great many condiments, and better still shell-fish (lobsters, crayfish) convey to the system a very appreciable quantity of organic phosphorus which replaces that which the invalid dissimilates rapidly. The same may be said of brains, sweet-bread, etc.

As to meat, it ought to be eaten partly roasted, partly raw. For this last, it is necessary to take mutton or even horse: it is scraped with a knife and made into a pulp from which five to six large pellets are made from 20 to 25 grms. each[1]; they are sprinkled with some drops of lemon or brandy *and are swallowed without being masticated at the end of the meal when the appetite is already satisfied.* It is the only method of well supporting this very important supplement of food. Raw meat brings with it not only its alible principles, but its assimilating ferments or very active exciters of the nutrition.

Bread, especially well baked almost entirely formed of crust, is an excellent food for tuberculous patients. Crust contains, it is known, about 13 per cent. of nitrogenous matters easily

[1] 250 grms. of butcher's meat grated, only give 120 to 140 grms. of quite homogeneous pulp deprived of tendons, membranes, etc.

digested and 67 per cent. of starch and dextrins. Bread is besides rich in nucleins, phytin and other phosphorated principles which make up the deficit caused by rapid dissimilation of the organic phosphorus of the system. Biscuits, rusks, etc., fill the same rôle.

Flours of leguminosæ, diastased or not, and seed vegetables (peas, haricots, lentils, decorticated beans, etc.) are also foods well fitted to restore rapidly the losses in nitrogen, phosphorus and carbon which exhaust these invalids. Of all the animal or vegetable foods, it is these which contain phosphorus under the most assimilable form (p. 210). From this point of view farinaceous vegetables are more valuable even than eggs.

As to the herbaceous vegetables, in these cases they fulfil a triple indication : they help to combat the constipation, often stubborn, which torments these invalids ; they bring them iron in the form of hematogen, that is to say under the form the best suited to combat anæmia and the alteration of the blood globules *without congesting the lung or exciting cough;* they contribute towards furnishing a large proportion of lime and magnesia necessary to the tissues, which in these invalids tend to become impoverished in these two bases.

Fatty bodies are indispensable to the tuberculous, especially if they have fever. Formerly they were made to take cod liver oil which their atonic stomach supported and digested badly. To-day cream, butter and other fat foods, when they can digest them, which may be rendered easier by a little old wine, are strongly recommended. Cream and fresh butter of such easy digestion thus permit of 80 to 100 grms., and more, per day of fatty matters being acceptable to these invalids without too much difficulty.

Coffee, tea, cocoa and red wine, which with their organic iron bring also their precious tannins ; sweetened dishes, brandy and alcohol in all its forms, but always in small quantities,[1] in a word all the foods called "sparing" are particularly useful to them.

If, however, there were any tendency to congestion, spitting of blood, threatened hæmorrhages or painful palpitations of the heart, it would be necessary to forbid too strong coffee and tea, wine and aromatic foods, as the koumiss, in the countries where it can be procured.

Wine and beer are generally favourable to consumptives ; it is necessary to choose generous wines but not sweet wines which quickly displease, load the stomach and diminish the appetite.

In the application of these rules of alimentation, there are difficulties which spring from different particular cases. The

[1] See on the subject of alcohol considered as very advantageous for consumptives, the work of M. Mircoli in *Münch. med. Wochens.*, 1902, No. 9.

principal is the want of appetite, with stubborn constipation at the beginning, and later diarrhœa.

We have previously said how necessary it is to excite the appetite by life in the open air, carriage drives, arsenic in its organic forms. Variety in food, the use of condiments of every kind, spices, etc., are also means not to be neglected if there is no dyspepsia.

As stimulants for the inert stomach, Vichy or alkaline waters which stimulate the secretion of hydrochloric acid, should be resorted to, also bitters, soups mixed with meat juice, chicken jellies, smoked and scraped ham, anchovies and other analogous condiments, caviare when possible, sauces seasoned with mustard, lemon juice, or other acid fruits, etc. Sometimes cold meats are better tolerated by these invalids than warm.

Scraped raw meat, *swallowed without being masticated*, as I have previously observed, is most often accepted by stomachs which refuse cooked meats (Debove).

Inability to digest, heaviness of the stomach, etc., flushings of the face may disappear, if the patient is given after the meal a little coffee, a hot cup of tea, a little pancreatin and a tablespoonful of a solution, in hydrochloric acid, of phosphate of ammonia and magnesia to which a little cognac, sugar and lemon juice have been added.

Against habitual constipation, sometimes very stubborn, the dietetic means are : herbaceous foods, the juice or broth of herbs, decoction of the flour of oats, fresh milk taken fasting and preceded by a glass of water : whey (500 to 600 grms. per day) mixed with 15 to 20 grms. per litre of lactose and, if necessary, a little Seidlitz powder or tamarind.

If, on the contrary, there is diarrhœa, the invalid may be nourished on milk alone, if he digests it well (sterilized milk suits best in these cases) or raw scraped meat, ham, red wine, tea, cocoa, etc. If the diarrhœa continues, the invalid should be put on a diet of milk soups, tepid broth with yolk of egg or gelatine added to it (10 to 15 grms. of the latter per day) decoctions of rice, quince jelly, milk of almonds, meat soups, etc. Pastry, sweets, fruits, seltzer water are unfavourable.

Such diarrhœa is often accompanied by intestinal ulceration which we can scarcely hope to cure.

If there is any vomiting while eating, it is necessary to try tonics for the stomach and especially ice in quite small pieces which must be swallowed without sucking. It is also necessary to divide up the meals and not to neglect medical treatment with which I have not to deal here.

We have already spoken of several of these conditions à propos of stomachic dyspepsia.

Severe cough will be combated by sips of a hot mixture of

milk and barley water slightly sweetened, and by the customary soothing agents, especially by the extract of hyoscyamus which does not weaken the appetite so much as opium or morphia.

I have previously stated what should be done in cases of hæmoptysis. When there is hæmorrhage, complete rest in bed with the shoulders raised, draughts of chloride of calcium (2 to 4 grms. per day), opium in a large dose and diet are indispensable to allow of the perfect repair of the vessels. In case of very few hæmorrhages, we must have recourse to injections of ergotine, afterwards of artificial serum, the latter to sustain, if necessary, the failing heart.

If there is much fever, rising to 39° and more in the evening, if it cannot be lowered by arsenical drugs (quinine is bad for these stomachs and besides useless; pyramidon cannot be continued very long; creosote lowers temperature but rapidly weakens the bodily forces), it is necessary to diet these invalids, to give only the small amount of food which they digest, to insist above all upon milk, to permit, if needful, a little cognac mixed with one or two yolks of eggs, which, with raw meat, jellies, decoctions of cereals as drinks, bread, creams of barley or rice, will form the basis of their alimentation.

Here is, as an example, the arrangement of a concentrated diet for tuberculous patients:—

Déjeuner, early:—Milk, 250 cc. Cocoa, 30 grms. Bread, 50 grms. Butter, 20 grms. Sugar, 25 grms. The yolks of two eggs swallowed whole after this little meal with 20 grms. of brandy.

Lunch at 12:—Roast meat or fish, 100 grms. Farinaceous vegetables, 60 grms. Bread, 120 grms. Butter, fat, 20 grms. Wine, 260 cc. Fruits, 60 grms.

Afternoon tea:—Milk, 300 cc. Cocoa, 30 grms. Sugar, 25 grms. The yolk of two eggs to be swallowed at the end of this meal.

Dinner supper:—Soup with 50 grms. of bread. Bread, 100 grms. *Roast* meat, 80 grms. Herbaceous vegetables, 100 grms. Butter, fat, 20 grms. Wine, 200 cc. Brandy, 20 grms. Fruits, 60 grms. 70 grms. of scraped raw meat to be swallowed without mastication after the meal.

At night:—Milk (if necessary), 150 grms.

For a tuberculous patient of average weight placed, owing to dietary and medication, in a condition to maintain his nutrition, the daily alimentation we here indicate can be thus expressed in Calories:—

Nature of the Foods.	Quantities in the fresh state.	Containing		
		Albuminoid Matters.	Fatty Matters.	Carbo-hydrates.
Milk	700 cc.	25·6 grms.	31·1 grms.	38·5 grms.
The yolks of 4 eggs .	70 grms.	11·2 ,,	21·4 ,,	0·6 ,,
Roast meat or fish .	180 ,,	37·26 ,,	9·7 ,,	0·6 ,,
Raw meat . . .	70 ,,	14·63 ,,	3·8 ,,	0·4 ,,
Farinaceous vegetables	60 ,,	12·0 ,,	1·2 ,,	35·4 ,,
Herbaceous vegetables	100 ,,	2·0 ,,	0·3 ,,	6·0 ,,
Bread (well baked) .	320 ,,	28·0 ,,	3·0 ,,	170 ,,
Butter, fat . . .	60 ,,	0·0 ,,	51·6 ,,	0·0 ,,
Cocoa	60 ,,	5·3 ,,	30·0 ,,	7·2 ,,
Cognac	40 ,,	0·0 ,,	0·0 ,,	40 ,,
Sugar	50 ,,	—	—	46 ,,
Wine	500 cc.	0·0 ,,	0·0 ,,	80 ,,
Fruits	100 ,,	0·2 ,,	0·1 ,,	7·0 ,,
	Totals	135·99 gms·	152·2 grms.	431·7 grms.
	Corresponding Calories	544·3	1,354·5	1,725·6

This ration corresponds to 3,624 Calories. It is ample in the bulk of cases and largely furnishes to the consumptive, especially if he is at rest, the nitrogenous, ternary, phosphoric and mineral elements suitable to make good his losses. It will be noted besides, how much the enormous proportion of fatty matter, destined to delay dissimilation and to supply the necessary Calories, is concealed in this alimentation.

The concentrated ration which has just been indicated admits too of innumerable varieties.

In *osseous-tuberculosis* the diet should be very substantial; the same as in chronic pulmonary tuberculosis.

The dietary of the consumptive should contain as much salt as possible, salt being very effectively opposed to the dissimilation of albuminoids and facilitating the excretion of nitrogenous waste products.

It has been repeatedly written and said: every tuberculous patient who eats well and gains in weight is curable. This is unhappily not quite an exact statement. But it may be said that among these invalids, resistance is proportional to appetite and to the digestive powers. Those only live long who feed well.

XLIII

DIET IN CASES OF ANÆMIA, CHLOROSIS, SCROFULA, RICKETS, OSTEOMALACIA, SKIN DISEASE, SYPHILIS AND CACHEXIÆ

Anæmia, Leukæmia, Chlorosis.

ANÆMIA.—The anæmia which is caused by an insufficient and improper alimentation, as well as that which follows loss of blood from any cause whatever, may be made to disappear under the influence of a healthy and abundant diet. In such cases albuminous foods are the more necessary, as in general anæmia and hæmorrhage accentuate nitrogenous dissimilation. We know that by bleeding, the phenomena of oxidation become accelerated, at least for some time. In these cases then the subject should take complete rest in order that he may provide oxygen according to his needs. These remarks apply especially to anæmia provoked by fairly large hæmorrhage of every kind.

In cases of chronic anæmia it is certainly necessary to try to feed the patient well, but it must be remembered that in such cases the nervous system kept in bad repair reacts on the stomach which has in part lost its digestive power. Exciting dishes, roast meat, raw meat (150 to 250 grms. daily), generous wines, strong beer of good quality, and in general all concentrated nourishing substances : fresh eggs, milk in a small proportion, purées of vegetable flours, green vegetables which bring at the same time phosphorus, and salts of lime and magnesia, underdone meat, meat soup, fish, cooked cheese, etc., may prove satisfactory for these weak stomachs. These invalids need only abstain from indigestible foods in great quantities, those which are too fat, starchy or sweet.

Iron is necessary to anæmic persons, and we have already stated that apart from medicaments, red wine and green vegetables both furnish an appreciable proportion of it under an organic and easily assimilable form. We have given (p. 329) the amount of iron in the different alimentary substances.

Of the foods, blood and meat are much the richest in this element. Milk, on the contrary, is one of the poorest. The enormous amount of milk necessary to give sufficient nourishment brings so much liquid, that this alimentation fatigues the heart and the kidneys, as well as the stomach and the intestines of

which the muscles are already weakened, as the obstinate constipation from which anæmic and chlorotic subjects so often suffer, proves.

The alkalinity of the blood of anæmic persons is almost normal.

According to Danford, Fraser and Ehrlich, the taking of the raw bone marrow of young animals (10 to 15 grms. of fresh marrow of the tibia of the calf) enables us to combat usefully certain serious forms of anæmia and chlorosis itself by rapidly regenerating the red blood corpuscles.

Leukœmia.—The influence of alimentation on *leukœmia* is somewhat slight. Preparations of iron (oxalates, lactates) and ferruginous foods are again indicated here : but it is above all necessary to grapple with the initial cause of this condition where the hæmatogenous elements of the system seem to have lost their aptitude to reproduce the red corpuscles. It must also be borne in mind that in this ailment, the formation of uric acid becomes exaggerated. It would appear then that leukæmics should avoid foods in nucleins : too young meats, gelatinous tissues, broth and extracts of meat, sweetbread, etc. Milk on the contrary may be taken.

Chlorosis.—Chlorosis is generally a complication of anæmia ; it should be treated in the same manner from an alimentary point of view. In these cases, underdone meat, and better still mutton and horseflesh, raw or scraped, produce the best results. To these foods, the following may be added : Green vegetables, meat juice, eggs, cheese, good red wines of Roussillon or Bordeaux, two years old at most, wines very rich in iron and tannin. Salt, and particularly common kitchen salt, the most arsenical according to my investigations, and salted foods in general are also very beneficial to these subjects. They excite the appetite and hinder an excess of nitrogenous dissimilation. But above all chlorotic persons must be made to eat ; and it is in such cases that a stay in the open air, particularly at the sea-side, and very small doses of organic arsenic (1 to 2 centigrms. daily of disodic methylarsenate or arrhénal) render the greatest services.

The alkalinity of the blood of chlorotic patients is normal and even a little above normal (Kraus, Rumpf). It is not then in this direction that the treatment or alimentation of these subjects should be guided.

As they generally store up very few foods, they should not take too much exercise ; what they require is carriage drives in the open air, a stay in the country or by the sea-side, an open air life and moderate exercise without fatigue.

Scrofula, Rickets, Osteo-Malacia.

Scrofula.—Scrofula is generally the result of an alimentation which is defective, insufficient and too rich in herbaceous or

starchy foods. It is prevalent among the poorer classes who eat bread of an inferior quality (sometimes mouldy) and little meat, drink either no wine or beer or too little of it, and live in damp, unhealthy and ill-lighted premises. The use of bad milks coming from diseased and tuberculous cows, or milks diluted with impure water, also contribute to develop this affection.

Scrofulous persons require air, light, sunshine, sea air, foods rich in nitrogen and phosphorus (grilled meats, ham, fish, soups, good milk, eggs, cheese, good bread, red wines, coffee, cocoa) and alimentary stimulants : bitters, iodine, arsenic.

These patients should not take foods of bad quality, sweetmeats, acid fruits, vegetables which contain too much water or starch (rice, potatoes, etc.), doubtful milks.

Rickets, Osteo-Malacia.—In *rickets* the quantity of lime of the bony tissue diminishes considerably. The calcic phosphate of the bones may fall from 57·5, the normal figure, to 14·5 per cent., whilst the organic matter increases from 33·5 to 72 per cent. But although it has been demonstrated, particularly by the experiments of Haubner and Voit,[1] that young animals deprived of salts of lime become subject to rickets, Rudel,[2] Uffelmann and Baginsky [3] have established, on the other hand, that rickets may appear in children even when fed on an alimentation rich in salts of lime which, in these cases, they throw off abundantly by the urine. As a matter of fact, this disease essentially consists of an exaggerated proliferation of the elements of that part of the cartilage in young animals which is destined to become bone, and which never reaches the state of transforming itself into bone or absorbing the lime, due to a cause which is as yet unknown to us. Is it the insufficiency of the stomachic secretion of hydrochloric acid which hinders the assimilation of foods, as has been suggested ? Is it the too abundant production of lactic acid formed in the stomach by reason of secondary fermentations, an acid which, reabsorbed in the intestine, acidulates the blood and prevents deposits of phosphates and calcification ? This theory has been upheld with some reason by Heitzmann, Hoffmeister and Baginsky.

It appears then necessary that these patients should avoid all foods which may undergo in the stomach acid fermentations, lactic or butyric : sweetmeats, indigestible foods too rich in cellulose and starch, green fruits, cow's milk substituted for human milk, frequent change of wet-nurse, lacteal diastased or other flours. Whether fed at the breast or on sterilized milk, the infant should be examined to see if he gains regularly in weight as much as is suitable to his age. Above all, care must be taken not to burden the stomach of a young child with foods *he cannot digest.*

[1] *Zeitsch, f. Biolog.*, Bd. XVI, p. 62.
[2] *Arch. f. Path. u. Pharm.*, Bd. XXXIII, p. 90.
[3] *Prakt. Beitr. z. Kinderheilk.*, 1882.

In default of human milk, ass's milk, or if need be the freshly sterilized milk of healthy cows, may be used, but the latter with prudence. The pulp of raw meat from the twelfth month, if necessary roast scraped meat, eggs, broth and panades of white (torrefied) bread, purées of peas or lentils, a little Malaga or port wine, but very little—just to stimulate the digestion, constitute favourable foods or stimulants. Phosphated flours, or those naturally rich in organic phosphates, are strongly indicated. Hygienic care, open-air life, sea-air, salt and aromatized baths with the special therapeutic treatment, in these cases, are the most suitable adjuvants of this regimen.

In *osteo-malacia* the earthly salts of the bones diminish and the organic substance becomes modified. It increases a little in weight and appears to be no longer able to furnish gelatine on boiling.

The lack of calcareous material in foods leads, in the case of adults, to a veritable rarefaction of the bone which does not become soft, as in the preceding case, but brittle : this state is called *osteo-porosia*. It is easily dealt with by the use of calcareous foods (milk, bread, herbaceous vegetables, preparations of glycero-phosphates, etc.), a diet which also suits persons afflicted with osteo-malacia.

Skin Diseases, Syphilis.

Many skin diseases are caused by a defective alimentary diet : excess of fatty bodies, fish, shellfish, spices, meats, especially of too young animals and particularly veal, high game, etc., produce urticaria, eczema, impetigo, etc.

Although a defective alimentation is not in itself sufficient to produce eczema, it always aggravates and develops it in persons predisposed to it, in arthritics for example. What must be avoided in these cases is fish, shellfish, too young meat, pork, game, strawberries, fermented cheese, pork-butcher's meats, chocolate, coffee, beer, all highly spiced, too fat or too nourishing dishes. Wine should only be taken in very moderate quantities.

Veal is particularly apt to encourage eczema and to cause persistent eruptions of acne to appear, to irritate the intestinal mucous membrane and that of the urinary passages. It is for these sufferers that vegetable diet is especially indicated, without however beef or mutton being forbidden any more than wine. As adjuvants, the use of alkaline mineral waters or arsenical waters or preparations may be advised.

The very fat milks of some wet-nurses cause an eczematous rash in infants. In these cases it is better, if their age permits of it, to put them on sterilized milk, panades, milk foods and even raw scraped meat.

In all skin diseases it is necessary to avoid exciting dishes or those

which provoke an elimination of irritant matters by the cutaneous surface or by the mucous membranes. Under this heading are aromatic spices, bitter condiments, the flesh of too young animals, fish—especially if it is not quite fresh or too fat—crustacea, mussels, and with some people yolk of egg, etc. Strawberries often produce urticaria in those predisposed to it.

Among vegetable foods all those which bring oxalic acid must be avoided (sorrel, spinach, rhubarb, beetroot, French beans).

The excess of nitrogenous alimentation with the exclusion of vegetable foods, especially provokes constipation and reabsorption in the intestines of matters undergoing more or less putrid fermentation which are particularly irritating ; these the skin finally eliminates while partly oxidizing them, but not without harm to itself.

The *true pellagra* or endemic pellagria is connected with alimentation by maize which is invaded by a mould called *verderame* or *Ustilago carbo* (Balardini, Th. Roussel, Costallat).

Although the consumption of *rye bread* is decreasing in France, 2,000,000 hectares are still given up to the cultivation of this cereal and many persons eat also, at certain meals, rye bread or meslin as a refreshment. It is known that the grain of rye may be infested by the scleroid mycelium of a poisonous mushroom, the *Claviceps purpurea*, and that the bread which is produced may provoke endemics of ergotism with gangrene of the extremities.

Syphilis.—In this disease, specific treatment is much more important than diet, which may be of quite an ordinary character. However it is very evident that if it is a question of an arthritic, obese, anæmic, cardiac person, etc., the regimens suitable for those conditions are indicated above all.

For young syphilitic nurslings, if they are not nursed by the mother, they should be put on a diet of ass's milk or sterilized cow's milk which may be mixed with a third or a half of toast water and a little sugar of milk.

CACHEXIA, SCURVY, CANCER.

Cachexia, Scurvy.—As in the preceding disorders, cachexias are above all susceptible to the specific medication corresponding to the cause from which they originate. The cachexia of myœdema, for example, may be successfully combated by the taking of thyroid gland : alcoholic cachexia may yield to the deprivation of fermented liquors ; mercurial and saturnine cachexias to cessation of the use of the preparations of mercury or of the absorption of lead by the mucous membranes and the skin.

In nearly all these cachectic conditions, roast or raw meat, eggs, milk, good bread, red wines in moderation, are the foods most indicated and the most valuable.

There is a special form of cachexia which particularly results

from an unhealthy alimentation : this is *scurvy.* It appears to be the result of insufficient feeding both as to quantity and quality combined with a lack of hygienic care, excess of fatigue and moral depression, so many causes which render assimilation and nutrition defective.

It has been stated that epidemics of scurvy disappear almost immediately on the return to a diet of fresh meat and vegetables. From the fact that on salt meats being replaced by fresh meats and vegetable foods, the scurvy was generally very quickly cured, it has been concluded that salted meats were the cause of this disease. From the fact that when fresh vegetables were brought to a crew or besieged town, the epidemic of scurvy was not long in abating, it has been inferred that scurvy was the consequence of a lack of fresh vegetables, and particularly of those richest in salts of potash, such as potatoes. But we must again bear in mind that fresh meat assimilates better than salt meat [1] and that the latter is only reparative if it is in a good state of preservation, quite free from the products of more or less advanced decomposition and from toxins ; that meat alone, fresh or salted, *is not properly assimilated if at the same time a certain proportion of herbaceous and starchy foods are not included in the diet.* We have established this fact at some length in Part I of this work. Vegetables in these cases appear then to excite and improve the assimilation which the combination of different causes had helped to impair ; they also act by alkalizing the blood and accelerating the phenomena of oxidizing fermentations.

In order, then, to avoid scurvy the diet should be sufficiently reparative, both animal and vegetable. If either preserved or salted meats are included in the diet, it will be necessary to be satisfied that they are in a good state of preservation ; that they were not fermented before salting ; that they are not unpleasant either to the eye or taste ; that the provisions have not become changed from having been kept too long, which by allowing the diastases to act upon them may have modified these meats by partly transforming them into starchy bodies which are little or not at all assimilable, and sometimes even poisonous. Fresh meat should be given in place of these old preserved goods as soon as it is possible.

It is especially necessary that the alimentation of the sailor, soldier, the besieged and the explorer, should contain a sufficient quantity of preserved vegetables and better still, if possible, fresh herbaceous vegetables themselves. Lacking these, potatoes will render this service. If necessary peas, lentils, cabbage, onion, garlic, spinach, sorrel, cardoon, chicory, lettuce or different fruits

[1] Mr. Vincent has just proved, however, that salt introduced into the blood or under the skin, is favourable to the invasion of the system by infectious microbes (*Soc. de Biolog., Séance* of June 4, 1904).

may be replaced by decoctions of fir and bilberry buds, and if need be of common grass, moss, lichen and conferva brought by the sea, etc. Among fruits the most valuable are apples, plums, pears and especially lemons, oranges and grapes. Fresh or concentrated milk, grain and flours of cereals are also clearly indicated. Finally, wine and beer should be taken directly it is possible to do so. Wine by its richness in acid tartrate of potash and its easy preservation, is the most valuable alimentary drink as a prophylactic and cure for scurvy.

As for beer it is more difficult to carry from place to place and to keep. A kind of small beer called *epinette* can be made on the spot, at least in fir and pine countries, from the following recipe given by Duhamel du Monceau : Into a large cauldron of boiling water a large sheaf of pine or fir leaves is plunged. On the other hand a bushel of oats is cooked in a saucepan over a fire, and also 7 kgs. of bread cut into rather thin slices are grilled on a hot slab. The whole is crumbled into the water of the cauldron, which is boiled for thirty minutes. The liquid is then skimmed, left to cool and poured into a Bordeaux cask. A watery solution of 5 to 6 lb. of molasses and 12 to 15 lb. of sugar is added. When the mixture is only tepid, the must from a litre or two of yeast of beer mixed in water is added (if necessary, this yeast may be kept in a very dry state) ; the cask is filled up to a few centimetres from the bung with tepid water, and left to ferment. After a few days the liquid is ready to drink. It constitutes a sort of light beer which may prove useful.

Cancer.—The evolution of cancer *and the cancerous cachexia* which follows it may be checked by sufficient feeding. Generally it is necessary to restore the appetite (which is often lacking in cancerous persons) by means of bitters or even preparations of organic arsenic. They must then be allowed to take as far as possible the food which suits them and which they can digest best. In a general way the regimen which we have indicated (pp. 440, 469) for dyspeptics and tuberculous consumptives is suitable in this cachexia.

It is not certain that the vegetarian diet recommended to these invalids by Beneke is altogether favourable to them. However as cancerous cachexia is due to the reabsorption of toxins which form in the organs invaded by the neoplasm, it seems logical to sustain the invalid by the alimentation which brings the smallest amount of nitrogenous residue to the system, that is to say by milk and vegetables. Again it is necessary that the patient's stomach should be satisfied and that this regimen should not help to weaken his already impaired forces.

XLIV

DIET IN NERVOUS AFFECTIONS AND MADNESS

EXCESSIVE intellectual work, anxieties of every kind, an idle life, repeated nervous excitements and the consequent exhaustion, loss of sleep, the abandonment of all fatiguing or stimulating exercise, unwholesome diet with an excess of muscular flesh, etc., contribute to create the jaded and neuropathic. Congenital weakness, all the causes of anæmia, the too exclusive methods of alimentation, the abuse of stimulants, of alcohol in particular, may little by little modify the nerve cells to the extent of causing a whole series of pathological conditions, from nervousness and over-excitability to insanity, a well-known result of the repeated abuse of fermented liquors. In all these cases it is worth while to look carefully into the question of diet sometimes as an efficient or occasional more or less direct and continuous cause of these nerve troubles, and sometimes as a means of improving them.

Neurasthenia.—Physical overwork brings lassitude, depression and want of appetite, but rarely leads to neurasthenia. Intellectual overwork, associated with want of exercise, acts otherwise: if alimentation is abundant or moderate, income may very appreciably exceed expenditure; organic dissimilation, oxidations, become incomplete and the excretory matters with raised molecular weight, generally offensive, soon accumulate in the tissues and plasmas, and render their action abnormal.

The frequent repetition of emotions of all kinds, grief, business anxieties, the exaggeration and cultivation of excessive feelings from literary and artistic to erotic and depraved, the want of sleep, etc., act in the same way on nutrition and disintegration.

Everything which troubles directly or indirectly the digestive and assimilatory functions appear to bring about an exaggerated production of nitrogenous waste materials proved by the toxic state of the urine. These substances, almost all harmful and of a semi-alkaloid nature brought to the organs by the blood, act on the nerve centres and cause irritation, slow intoxication and loss of equilibrium. In particular, irregularity of the functions of the stomach, intestine, liver, kidneys, generative organs and their connexions, with exaggerated

alimentary excitation and want of exercise, are frequent causes of neurasthenia.

Without occupying ourselves here with the medical, physical or moral measures which may be employed in all these cases, the preceding considerations show that in these invalids it is necessary to provide the stomach with foods easy of digestion, sufficiently nutritive, but producing the least possible quantity of nitrogenous waste.

Neurasthenia being like arthritis, gout, chlorosis and obesity, a malady of degeneracy by weakening of the nutritive functions with exaggeration of the nitrogenous alimentation of which sufficient exercise does not assure the dissimilation, it appears that it is necessary to diet neurasthenics in the conditions recognized as the best for each of these different maladies, the more so as dyspepsia is their common appanage and is sufficient to bring about neurasthenia when there is an hereditary defect.

Finally, if it is observed that confirmed neurasthenics end by only being able to eat enough by the aid of stimulants, of condiments in particular, and that they only assimilate from that time a small proportion of the nourishment which they take in, as is proved by the small proportion of nitrogen which they eliminate by the urine and the exaggeration of the part of the nitrogenous bodies precipitable by the reaction of the alkaloids, it may be concluded again, from this point of view, that these invalids require a regimen of easy digestion, moderate rather than excessive, a regimen which may be gradually increased in proportion as the assimilative and nervous forces return, and as the organic residues better and better eliminated approach normal types.

From these observations the treatment of Weir-Mitchell and Playfair is derived. The invalid is isolated, put to complete rest in bed, he receives first, in small portions at a time, 1 to 2 litres of milk per day, conditions which are intended to reduce to the minimum the consumption of nitrogenous principles, whilst having recourse to those which give the minimum of wastes and toxins. The milk may be skimmed, cold or hot, sweetened, salted, with a little vanilla or caramel, etc., added to it according to the taste of the patient. At the end of three or four days, some farinaceous dishes may be added to the milk ; vegetable soups, one or two eggs, a little raw or roast meat, tea, coffee, cocoa and even wine with a little bread or biscuit. We must be especially guided by the state of the stomach and of the digestive functions which may be excited at the same time by electricity and massage. The proportion of food allowed is thus gradually increased until it reaches per day 300 grms. of meat, 200 to 250 grms. of vegetables or stewed fruits, 500 to 800 cc. of milk, two glasses of good cider or one glass of generous wine, white or red ; in

these conditions it is possible from the third or fourth week to allow the invalid to get up and walk a little.

This is then a cure which tends to reduce to a minimum the needs as well as the expenditure of nitrogenous alimentary principles, and consequently their offensive residues.

It does not succeed in the case of true melancholia or insanity, nor in certain forms of hysteria with vomiting, or epilepsy.

These invalids must never be permitted a succulent regimen, above all a regimen rich in meats which would act on the nervous centres by the irritating nitrogenous substances which necessarily arise from them, substances especially dangerous to those invalids whose digestion and assimilation are imperfect.

A fortiori will it be necessary to avoid, if not the very moderate use, at least the abuse of alcoholic drinks, the repeated stimulus of which is sufficient, in those predisposed, to provoke alterations of the nervous centres.

Whey, light chicken broth, frog's muscle, seed or herbaceous vegetables, compotes, fruits . . . in a word, the modified vegetarian diet; and for beverages: extract of malt, light wines mixed with plenty of water and acidulated drinks, form the best diet for these invalids. This was indeed the regimen of people attacked by *vapours*, as it was called in old times. Preparations of casein may be added, which have the great advantage of not fatiguing the liver and not giving appreciable nitrogenous residues of an objectionable kind.

The painful affections of nerves (sciatica, facial, dental and visceral neuralgias, etc.) are largely influenced by alimentation. Every one knows how often the pains become aggravated at the time when digestion furnishes the blood with the maximum of nutritive matters. In the same way that they over-excite neurasthenics, regimens of too succulent a nature or too nitrogenous, especially when joined with an idle life, increase hysteralgia and all neuralgias in general. They keep up gastralgia if they do not originate it. The modified milk diet with 100 to 120 grms. of meat at most per day, vegetable broths, vegetable jellies, fruits, and in general the vegetarian diet, are favourable in these different cases. These invalids besides require foods such as milk, peas, lentils, etc., which give sufficient nourishment since anæmia is a condition which over-excites the nerves.

In essential asthma, in addition to medical treatment where arsenic, especially under organic forms, works wonders, little meat is required, no alcohol, but foods of easy digestion. But tea and coffee are useful rather than harmful.

Insanity.—The demented, melancholics and epileptics are almost all anæmic, dyspeptic, arthritic and most often uricemic and oxaluric. Adler [1] has found daily, in the urine of a neuras-

[1] *Med. Record*, 1893, XLIII, 673.

thenic, 0·44 grm., in that of a melancholic, 0·75 grm. of oxalic acid in place of 0·015 grm. which is the maximum rate in the normal condition. The diet generally suitable in the aforementioned nervous affections is then that which should be prescribed for these patients. But special care must be taken that all gastric trouble and all constipation are avoided: hence the very sensible use, in cases of insanity, of milk, green vegetables, prunes, fruits and marmalades, etc. But these persons require a very substantial alimentation and all the more nourishing according to the state of restlessness or depression. In the depressed forms of anxious melancholia, in the case of epileptics and those whom agitation deprives of sleep, foods should be very nourishing, rich in assimilable phosphorus, an element that these subjects lose abundantly. Dry vegetables, and especially lentils and pea purées well supply this need.

Insane people, and especially insane alcoholics, must abstain from all fermented liquors as well as all exciting foods. Eggs, meat in small quantity, dry vegetables and the modified vegetarian diet, constitute the most favourable diet.

If we remember the examples which I have given as to the changes of character of animals under the influence of foods (p. 376), the bear and the rat fed on meat becoming violent and ferocious, whilst they remain mild and tractable with a vegetable diet, we can understand the advantage which may be derived from vegetarianism among restless and dangerous lunatics.

For the madman who refuses food, we are obliged to resort to the œsophageal tube introduced by the mouth or nasal passages (see Chapter XLIX). Dried meat and casein powders, milk, the yolk of eggs mixed with soup, vegetable purées, all foods which give good nourishment in a very small volume, are all naturally indicated in these cases. But feculents, which these invalids cannot digest well, should not be used too much, and if fats are given to them by this means, they must only be administered under the form of emulsions.

XLV

DIET IN ACUTE DISEASES—RULES RELATING TO DIET IN FEVERS IN GENERAL

ACUTE febrile diseases generally end favourably if no indiscretions are committed and no unforeseen complications arise. Contrary to what holds in chronic diseases, the regimen here ranks only second in the sense, that for all fever patients, it varies but little the diet or rather a very light alimentation which allows of supporting the invalid without stopping the efforts the organism makes to return to the normal condition, being the rule in the greater number of cases. Also it may be said as regards quantity, most febrile patients may be fed alike. Thus the great English physician, Graves, has been able to sum up their regimen in the few following lines :—

"In the case of these patients, the alimentation should be controlled with care and precaution, especially at the commencement of the fever. From the first to the third day, especially if the invalid is young and robust, water, weak barley water, whey, will suffice. Afterwards a sweet alimentation ought to be given. What I generally prescribe is an oatmeal gruel very well cooked, sweetened with sugar and to this add, provided there is no tendency to diarrhœa, a small quantity of lemon juice. I am also in the habit of ordering a very light panade, night and morning, during the latter part of the first stage and towards the middle of the course of the fever. The patient takes two or three large spoonfuls of it per day. . . . Later a little meat juice or broth may be allowed. One of the best means of alimentation in the middle or towards the end of a fever, is chicken broth given in small quantities at a time and with precaution. If the result be heaviness, stomach ache, redness of the face, agitated pulse with increase of fever, this diet must be stopped and the gruel and panade again given to the patient. . . . Simple drinks are the only ones that can be given in cases of fever : beer, ale, porter, light wine diluted with water ; tea and coffee are frequently given to fever patients ; they are very useful when seasonably employed."

This statement of one of the most authoritative English practitioners sums up the regimen for fever patients, and we

see here that Graves makes no essential distinction between such and such a form of acute fever.

However, a few explanations and reservations are necessary.

In what quantity should food be given to fever patients? Formerly the regimen of a fever patient consisted of a diet of foods modified by the use of ptisans and broth. Abstinence from foods more or less complete has its advantages: it disencumbers the liver, intestines, lungs and brain: it lessens the work of the heart; it facilitates the reabsorption of toxins. But this diet has also its disadvantages: the fever consumes the tissues: the proof of this is given on the one hand, by the rise in temperature of the patients and the great quantity of heat that they lose even under conditions of absolute abstinence from foods, on the other hand, by analysis of their excreta. Krauss and Loevy have established that with fever patients put on slop diet, the absorption of oxygen and the elimination of carbonic acid are at least equal to, and sometimes higher than, what they are in the normal state. It has also been proved that in acute fevers, the dissimilation of total nitrogen and consequently proteid substances, as well as the production of waste matters having this origin, exceed by 8, 10 and 15 grms. per day at the commencement and especially at the critical period, the quantity of nitrogen furnished by the food. The fever patient then is burning, but he is burning his tissues, his proteid matters as well as his fats, as the abundant nitrogenous matters in the urine bear witness.

As for the heat lost, it is almost the same as in healthy persons left at rest, that is to say from 2,000 to 2,400 Calories per day.

This limited slop diet causes great anæmia. Denis found for 1,000 parts of blood in a young man: Before dieting, *blood corpuscles in the dry state* 154, *water* 770; after 40 days of this diet, *dry corpuscles* 111, *water* 804.

The fever patient must then be fed very little. Besides, we know that abstinence from food, when too prolonged, alters the mucous membrane of the stomach, and destroys its aptitude for secreting the gastric juice. An over strict diet weakens the patient and prolongs convalescence. Formerly, when abstinence from food was carried to excess, patients have been known to die of starvation. Buss, Von Noorden, Albrecht have proved that typhus patients and fever patients in general, lose less weight, have less fever and a shorter convalescence when they are fed even with nitrogenous foods, than when they are subjected to a strict diet, provided only that the foods are liquid and easy to digest, such as milk, panadas, light soups and good brands of peptons, etc.

"It appears to me," wrote Piorry (*Pneumonies des vieillards*), "that pneumonia patients when fed, make a better and quicker recovery than those who are not fed." Trousseau and Pidoux

in their turn speak as follows :—"It is necessary to keep to a strict diet so long as the changing forces of the system have to carry out the necessary pathological work . . . later on slop diet becomes harmful; it causes debility and nervous disorders which it does not do, so long as the forces of vital chemistry are occupied in digesting and feeding the pathological products."[1]

However, it is necessary to proceed with prudence in the alimentation of these invalids, for digestion and assimilation which in the normal state are hardly noticeable operations, are for them a heavy burden. The fever patient, like the overworked man, digests badly: he has no appetite, his salivary glands do not secrete, or secrete very imperfectly; his gastric juice, formed under bad conditions, is almost inert, poor in pepsins and hydrochloric acid (Rosenthal, Ewald, Klemperer, Wolfram). The liver no longer acts if the fever is high and serious; the intestinal secretions are partly exhausted. An overworked rich feeding fatigues the stomach made over sensitive by the fever; it rejects heavy, over abundant or over stimulating foods. This is the case with meat, meat juice, fatty bodies, wine, etc. The dyspnœa and syncopes which may result from the weakening of the nutrition of the heart, are also more to be feared during digestion. We must then only think of feeding these invalids a little more if their fever has become chronic, if it continues, if the patient is wasting. To think of giving them 20 to 30 Calories per kilogramme per day, as Von Noorden suggests, is a theoretical and often impracticable proceeding. Nourishment must not increase the fever, and as Graves says, this is the best guide for regulating the alimentation.

A second is the sensation of hunger; apart from alteration in the stomach and intestines as in the case of ulcer of stomach, typhoid fever, dysentery, etc., and in cases of insanity, the patient's appetite may serve to regulate the amount of food we allow him. However this is not an absolute rule; it should only be followed with prudence. The craving for meats and fats in the obese, for succulent dishes and generous wines in the gouty and arthritic, and bread in the diabetic, could certainly not serve us as a guide to their real needs. Nevertheless, with convalescent and fever patients appetite is always a good sign, and as a rule it should be at least partially satisfied.

On the other hand, in the case of some invalids who require to be fed, tuberculous and anæmic patients for example, hunger may be lacking and not sufficiently indicate the real needs of the system. Here again appetite cannot be a good guide, and a somewhat forced alimentation may become necessary. The rule is then that attempts at feeding should not increase the fever,

[1] Quoted by Lorrain, *Thèse d'agrégation de Paris*, 1857, p. 26.

produce intestinal disorders, insomnia, cause sugar or albumin to appear in the urine, etc.

Hunger during fever is not very rare, especially with young people and children. Often with this sign are associated depression of the pulse, circulatory troubles and the commencement of a fall in temperature. These are so many concordant indications that it is necessary to feed the patient a little more. These observations apply much more strongly still to the quite young child who rapidly consumes his substance and should be fed in a state of fever even before these signs begin to appear. He could not support fever diet for long: children digest during fever, and we ought not, in their case, to be stopped feeding them, save by disgust, vomitings and diarrhœa. Broth, milk diluted with water, very light vegetable or bread soups, cream, fruit, and meat jellies form the foundation of alimentation for young fever patients.

Foods Allowed for Fever Patients in General.—A light regimen of easy digestion is necessary for all stomachs that are starved, unused to food, weakened by fever.

Facts have proved that of all foods those best digested by persons suffering from fever are carbo-hydrates; those which are the least acceptable are the fatty bodies; proteid substances are intermediate. It follows that the regimen should provide these patients above all with sugars, starchy matters, broth and even meat juice and a little milk, but these latter always in a small quantity and deprived as much as possible of fats which, in their case, do not find their habitual dissolvents and disagree with them. Still certain fatty bodies, like cream and butter, may be used in fairly large proportions. The fear that alimentation raises the patient's temperature, only holds good when the foods are badly digested or too abundant, or if the digestive canal be particularly attacked (peritonitis, typhoid, gastric fever, enteritis). The albuminoids themselves are suitable, especially if the fever is prolonged and if the system has lost its nutritive reserves.

In the series of useful researches made on this subject, Bauer and Künstley [1] experimented on a typhus patient with a diet at first very poor in albuminoids and then successively richer. Here are the nitrogenous losses observed by them:—

Albuminoids in the foods.	Nitrogenous losses daily.
0·8 grms. . . .	13·9 grms. to 16·4 grms.
39·5 „ . . .	11·2 „ „ 11·5 „
51·7 „ . . .	6·3 „ „ 6·9 „

We see here this unexpected, almost paradoxical result, that the nitrogenous dissimilation diminishes in proportion as these patients are fed on products richer in nitrogen.

[1] *Deutsch. Arch. f. klin. Med.*, Bd. XXIV, Heft 1.

When the fever is of long duration (typhus, tuberculous), milk alone does not suffice. It may be partially and advantageously replaced by raw scraped meat, very lightly cooked eggs, peptons mixed with broth, meat or calf's foot jelly.

As a rule, it is advisable to allow fever patients only semi-liquid or liquid alimentation. Solid meats which require mastication tire them, and mastication as well as digestion remain insufficient in these cases. It is better then to feed these patients with broths, soups, purées, nutritious juices, beverages. Care must be taken too, that the meals are never abundant; they should be separated by intervals of about three hours and repeated four to six times per day, making them more frequent during the periods of abatement of the fever—in the morning for example. But the stomach should be empty every time it receives a fresh quantity of food.

The patient's sleep should not be interrupted, and even in cases of insomnia, he should not be fed during the night if it can be avoided, unless it has not been possible to feed him during the day.

To act otherwise is to postpone the moment when the patient returns to his regular habits of sleeping during the night and feeding during the day. However, this rule does not apply in cases of starvation or pressing need of food.

Care must be taken that the patient's intestines are regularly emptied and that the mouth is kept very clean.

The quantity of food should be regulated by the appetency of the patient and by the condition of his functions. Relatively to the weight of the patient, the quantity should be greater in the child who rapidly wastes away, and even in old people who have no reserves. Generally, and for an average patient in bed, 25 Calories per kilogramme of body weight per day, or the alimentary energy corresponding to 1,650 Calories in twenty-four hours, are quite sufficient.

It remains for us now to speak more particularly of the quality and nature of the foods most suitable to fever patients.

We have just seen that all foods of animal origin should not be forbidden. Broth and meat extract contain a series of principles which act as tonics of the heart and stomach, stimulants of the appetite, peptogens, light foods. It is stating nothing new to say that for a long time it has been recognized that broth was agreeable to fever patients and sustained their forces. But broth is like wine and coffee: it must be used without abuse. There was a time when it was customary to overload weak stomachs cloyed too with these substances with extracts, meat jellies, concentrated broths, consommés, etc. In this way these were introduced into the patient's blood, already charged with the waste products of the fever, not the essential part of muscular tissue as was supposed, but an excess of extractive and irritant principles, the

dissimilation of which remained imperfect and fatigued the stomach, liver, kidneys and heart.

We must not, in fact, think of feeding very much with meat juice and concentrated broths of beef, veal or chicken. These preparations contain but few grammes of proteid matters per litre. As has already been stated (p. 144) broth is a condiment and a tonic by reason of its sapid matters and its salts, rather than a food. The gelatine that it contains in a small proportion and with which it can be enriched, either by concentration or by direct addition, could not be assimilated by the cells unless it had been previously peptonized. Besides, it only constitutes a very incomplete food. Meat jellies salted, sweetened or flavoured, may certainly play a part in the total of the patient's alimentation, but it would not be possible to give them in a rather large quantity without provoking satiety and disgust. However, mixed with broth, lemon juice, sugar, white wine, cognac, etc., these jellies may prove of some service to the sick person and the convalescent. They are easily digested and may be prescribed in serious fevers.

As to the natural peptons which pass from the meat into its extracts, only a very small proportion of them is found in a cup of broth.

Manufactured peptons, when they are not bitter, peptonized foods, casein powders, may be added to the broth in small quantities to make it a little more nutritious. A yolk of an egg can be mixed with tepid broth.

Finally, broth soups may be made, less nutritious and less nitrogenous than the preceding, by the addition of sago, tapioca, ground rice, toast, etc. Meat broth is not always borne by the stomachs of fever patients ; in this case decoctions or broths of vegetables also called " *herb broth* " may be given instead. They are made by cooking in salt water the ordinary cooking vegetables (carrots, lettuce, potatoes, leek, etc., with the exception of cabbage) straining it and adding as required some light alimentary materials that we have just cited in connexion with meat broth.

Milk is not easily digested, especially if the fever is high. It should be given, in any case, deprived of butter by churning or skimming, diluted with water or tisane, with the addition, if required, of a little tea, cognac, kirschwasser if there are definite indications for these stimulants. A mixture of boiled skimmed milk and cognac is the nourishment indicated, when the patient can support it, in septic diseases, eruptive fevers, etc., where it is necessary to restore the failing strength without overcharging the blood with nitrogenous products. Alcohol, in these weak doses, acts at the same time as a food, an antiseptic and a moderate reducer of the temperature (Binz, Schmiedeberg, Riegel), and as a stimulant of the renal secretion. Milk is

a somewhat active diuretic, but, taken in rather large doses, it provokes gastric and cardiac troubles. Kephir, which presents the nitrogenous elements of milk in combination, in an advantageous form, with a small quantity of alcohol, could be utilized in many of the cases if the somewhat high proportion of its fatty matters are not contra-indicated. Milk of almonds, egg and milk, whey and butter milk, may be substituted for milk if the latter is ill supported by the patient.

Raw oysters, with or without the addition of lemon juice, form a light food that may be allowed to fever patients and to convalescents, provided they are very fresh and of good quality.

Vegetables in thin purée, potatoes, peas, beans, carrots, parsnips, tomatoes (with the exception of haricots and cabbages), as well as sops, soups of barley, of oatmeal gruel, wheat and rice (25 grms. of flour of wheat, barley or oats for 250 cc. of water) may be given to these patients in order to vary their alimentation from the time when the fall of the fever permits of their being fed a little more solidly. A little milk, yolk of egg, cocoa, broth, salt, sugar, vanilla may be mixed with these soups according to the taste of the patient. Again, after having boiled the gruel with water, an addition may be made of sliced fruits, plums, prunes, apples, cherries, etc., and a little sugar added. It should then be set on the fire again and put through a strainer before being given to the patient.

The flours of leguminosæ are more difficult to digest than those of cereals, and should not be given to patients if they have too much fever. They should be reserved for those who, afflicted with chronic fever, require a more plastic nitrogenous food and one richer than bread or flour of cereals. The same may be said of flour of cocoa which is not suitable for patients in a condition of acute fever.

The pungent condiments, pepper, pickles, etc., are naturally contra-indicated in the alimentation of fever patients whose stomach, heart and kidneys are fatigued by them.

Sugar as a rule does not long please fever patients except perhaps in refreshing lemonades. It is useless to force it on them. If they shrink from its too accentuated taste (and it is desirable nevertheless that sugar should enter into their alimentation), the ordinary saccharose may be replaced by glucose, and even by milk sugar, both of which are far less sweet for the same weight. From 20 to 60 grms. of these sugars may be given daily.

Acid fruits such as grapes, oranges, lemons, currants, raspberries, apples, pears, etc., *provided that they are very ripe* and that the patient only swallows the juice, need not be forbidden to fever patients, unless the condition of the alimentary canal contra-indicates it. This also applies to preserves, fruit jellies and even to certain condiments such as lemon, salt, vinegar, aromatics,

sweet spices, etc. The greater part of these adjuvants possess the great advantage of permitting variation in the alimentation of the sick persons and of diminishing their disgust and stomachic indigestion, of being refreshing and of alkalizing the blood which tends to become acidified during the fever. Fruits are easily digested when they are ripe, or well cooked, and if they are taken in moderation.

With these foods wine must be named, especially white wine mixed with four to five volumes of water and taken in very small quantities. It brings its cream of tartar, its free acids, its alkali ; it is agreeable through its acidulated flavour ; it acts as a tonic by its tannins and its alcohol ; it helps to slightly lower the temperature, to feed the patient and to revive his forces ; it is diuretic. "Beer, ale, wine, tea and coffee are frequently given to persons suffering from fever," says Graves, "and are of great help if properly used." But white or red wine, and always in very small quantities, is only beneficial if the patient's stomach bears it well. And this must always be the case. It is certain that great advantages may be gained by the use of wine and alcohol diluted with water, taken iced or hot, mixed with tea, etc., in adynamic conditions, whatever their cause may be, in septic fevers, pneumonia, influenza, catarrhal fever, especially at the commencement, toxic conditions with a tendency to collapse, the shivering period in attacks of malaria, typhoid fever, during convalescence, etc. Dr. Cabot (*Boston Med. Journ.*, July 23, 1903) arrives at the conclusion that in the case of fever patients, alcohol taken in small doses does not sensibly increase the arterial pressure ; that it raises neither the temperature nor the pulse, and that it never produces delirium. Abott and Micoli appear to have proved that in the case of animals, alcohol prevents infection through the pathogenic microbes. Alcoholic drinks are only absolutely contra-indicated in cerebral disorders, gastro-enteritis, acute typhlitis and with children and nervous subjects.

Wine and alcohol, too much neglected in France, far too much valued in Germany in acute diseases, do not act only as light anti-febriles and general tonics ; they have other qualities as well : they fortify the heart and excite the renal secretion, very valuable results in septic diseases. It has been experimentally proved that alcohol, far from raising the temperature, tends on the contrary to lower it. Finally it protects the system against nitrogenous dissimilation. Yet this precious agent must only be resorted to when it is necessary, and if the fever and stomachic hyperæsthesia allow it.

Beer may be given in nearly all chronic or acute illnesses. It should be forbidden only in meningitis, peritonitis, typhlitis, dysentery and also in the case of patients placed on milk diet.

We know that weak cardiac tension, whether it results from a feverish state or whether it comes from heart weakness, diminishes the renal secretion and contributes towards the retention of the poisonous urinary matters. By augmenting the sanguineous tension and the force of the heart, wine, beer, weak tea, coffee diluted with a great deal of water, broth and their alkaloids (caffeine, theophylline, theobromine, xanthic bodies, etc.) help to re-establish the normal condition.

The usual drinks of fever patients are water, aerated water—artificial or not—with the addition of fruit juices, tisanes and lemonades.

Pure water should not be recommended if the fever is prolonged. It helps to deprive the tissues of their minerals. Infusions of violet, mallow, barley, rice, decoctions of apples, pears, etc., taken cold or hot, are fairly well indicated if it is a question of quenching the thirst or ridding the system of its toxins. But tisanes and pure water do not successfully fulfil this latter indication if the arterial tension is too weak. Water mixed with a little coffee, tea, very light white wine, and in some cases with a little cold broth, is better than a sweetened infusion of violet or borage, and the patient may well prefer even pure water to this latter. It is best here to follow his caprice, or rather his instinct.

Nevertheless, the patient must not be gorged under the pretext of washing the blood with aqueous liquids which overload the stomach and intestines, increase the vascular tension, predispose to congestions and fatigue the kidneys and heart. But the patient should drink enough to dilute his urine and prevent overcharging of the kidneys and intestines. For the usual tisanes we may substitute hot or cold lemonades of lemon, orange, pomegranate, apple, currants, cherry, etc., decoctions of rice and barley and even *very weak* tea, which are agreeable to the stomach and aid its secretions. These beverages must be given either very hot or cold; but in this latter case, there must be neither lung congestion, diarrhœa, dysentery, nor visceral rheumatism, etc. Drinks simply tepid weaken the stomach. Hot drinks should be resorted to, especially when it is necessary to excite sweating and to warm the patient.

The diet of the fever patient approaching convalescence is often a delicate matter to regulate. This is the time when, judiciously administered, milk, starchy soups (sago, barley, tapioca, ground rice, etc.), vegetable purées and later, fowl or lamb, boiled fish, light dishes, brains, scraped ham, cooked cheeses (Gruyère, etc.), pulp of cooked fruits, old and tonic wines, can render real service.

XLVI

DIET IN DIFFERENT FEBRILE DISORDERS

ALTHOUGH it is apparent that in acute febrile conditions the regimen we have just indicated, always remains nearly the same, there are variations necessitated either by the condition of the invalids or by the nature and seat of the lesion, particularly when it lies in the intestine or brain. It is these special cases which I now propose to review.

Acute Lung Diseases: Pneumonia, Influenza.—In *pneumonia*, warm decoctions of barley or toast water suffice for the first two days ; but from the time the pulse becomes small, weak, rapid and irregular, and even before these symptoms of heart weakness appear, and before there is any tendency to collapse, the patient must be sustained by alcoholic beverages taken in very small doses at a time, but repeated, such as old wines diluted with water, champagne cognac (30 to 120 grms. per day for the adult), etc., mixed with tea or broth. If needed, weak coffee with very little milk, and milk itself mixed with water, are excellent if the patients can support them. Milk is diuretic and its digestion fatigues the intestines, liver and kidneys very little. Again, these invalids may be given decoctions of alimentary flours in milk, water or broth, especially if the pneumonia is prolonged. As was stated in the preceding chapter, there is no necessity to fear a rise of temperature in feeding or in giving wine or cognac, experience having proved the contrary.

From the time the fever abates soups, vegetable purées, creams, raw meat, must again be resorted to. This tonic, diuretic, antiseptic and sufficiently solid diet is still more necessary in the case of old people and children suffering from lung disease.

In pneumonia of the grave infectious type, alcoholic drinks, Todt's potion, etc., are particularly indicated. Taken with quinine and extract of quinquina, they raise the strength of the patient and resist intoxication (Huxham, Laenec, Behier, Todt).

Persons suffering from pneumonia must avoid everything which will provoke the cough ; drinks too sweet, too salt or too cold, spiced dishes, etc.

Decoctions of barley, toast water or slightly sweetened water, are indicated during the first two days in lobular pneumonia

of children, especially if there is a tendency to vomiting and diarrhœa; they can be fed later with decoctions of flour. Milk with them is often the cause of intestinal troubles.

The same regimen is suitable in pleurisy. If there are false membranes or effusions, the patient must be given not only milk and a little white wine, which act above all as diuretics, but roast meat, broth, eggs, at least from the time when there is no, or very little, fever. Persons with purulent pleurisy should be put on the same diet as chronic tuberculous patients, that is to say, the most solid alimentation the patient is able to support.

In febrile *bronchopneumonia*, milk, broth, meat and fruit juice, grogs, generous wines mixed with water, tea, etc., are strongly indicated. The bronchopneumonia of old people requires the same regimen with the addition of scraped meat—roast or raw.

The preceding rules are also applicable in cases of croupous pneumonia. Only the milk should be replaced by raw scraped meat, mixed or not with tepid broth, white or red wine, and even cognac.

In *Influenza* distinction must be made between the nervous, cardio-pulmonary and intestinal forms.

In the first, the patient should be toned up, and the kidneys made to act by abundant drinks slightly alcoholic, sharpish and diuretic (couch grass, cherry stalks, aerated waters); the alimentation is almost the same as in acute pneumonia. In order to keep up the patient's strength, to relieve the heart and excite the renal functions, milk should be taken. To this, wine and even coffee may be added unless cerebral, nervous or nauseous phenomena predominate, in which case it is better to keep to milk diluted with ptisan of lime flowers, violets or orange flower or even with simple ptisans, etc.

In the intestinal forms of influenza, the regimen is the same as in gastro-enteritis.

If there is *adynamia*, it is advisable to insist on tonics, alcohol, coffee, caffeine.

Febrile Tuberculosis.—We have already stated (p. 469) how the tuberculous patient ought to be fed. Fever is not in this case a contra-indication to concentrated alimentation, quite the contrary. Only these patients must not be allowed to take any but small meals and should repeat them every four hours.

Dyspepsia and anæmia often impede their alimentation. But it is said that the pulp of raw scraped mutton taken at the end of a meal without mastication (100 to 120 grms. twice a day) is borne by nearly all these invalids. It is for them the most valuable of foods. After raw meat comes milk, cocoa, chocolate, the yolk of eggs, roast or smoked meat, butter, cream,

decoctions of flour of leguminosæ, malted or not; very ripe fruits if they can be digested. The milk should be taken as a drink, while eating or between meals, with a little coffee or cocoa powder. But pure milk or very hot strong tea would increase the fever. Bread which brings its phosphates, generous wines, beer, cognac if needed, but in small quantities and as a digestive, kephir may also be recommended.

Diffusible stimulants should be avoided if there is any tendency to hæmorrhage.

The diet of dyspeptic hypochlorhydria (p. 438) is usually that which agrees best with these patients who lack appetite.

If diarrhœa comes on, the cooked meats, milk and eggs must be provisionally abandoned and replaced by raw scraped meat or the juice of fresh meat pressed raw, albuminous water, water and cream of rice, broth with the addition of sago, the white decoction of Sydenham, tea, and returning slowly to the ordinary diet, when the diarrhœa has completely disappeared. If there is a tendency to hemoptysis, wine and too hot or aerated drinks must be avoided.

These patients should be so much the better fed the more fever they have, but on condition that the foods given to them are well taken, well digested and not in excess, and that the alimentation does not cause a rise of temperature.

Rheumatism, Pericarditis, Endocarditis.

Acute Articular Rheumatism.—During the acute period of this disease, a milk diet is the only logical one. It produces the minimum of toxins and increases diuresis. Again it is necessary to digest the milk. As drinks, citronade or the alkaline waters of Vichy, Boulou and Vals.

The rest of the regimen is that of ordinary pyrexia. When the temperature has fallen, the patient is fed as during convalescence from eruptive fevers.

Acute Pericarditis and Endocarditis.—Milk again constitutes the best regimen in acute pericarditis, but the quantity must be reduced to 1 litre per day at the most. Different flours, a little cocoa, coffee, tea, and even cognac or kirschwasser, may be added. When there is cardiac insufficiency, broth is not favourable.

In acute endocarditis it is again milk and milk foods which best sustain the patient. Broth and meat juice rank second. The juices of fruits, acidulated ptisans (citronade, orangeade) are very favourable here. Later, eggs, boiled fish, light meats, vegetables, coffee and tonic wines may be allowed.

In disturbances of compensation one can add to the milk diet a little raw or lightly grilled scraped meat (200 to 250 grms. per day), but it must be remembered that as soon as the arterial

tension becomes insufficient, renal elimination becomes so too, and consequently it is necessary in these cases to reduce to a minimum the substances such as meat and broth which are the origin of nitrogenous waste in the system.

Acute Meningitis.—In acute affections of the brain, the patients usually have nausea or vomiting, constipation and thirst. The first few days their food should be diminished inasmuch as the appetite is lacking, there is much fever, and it is important to reduce the cerebral congestion. Weak liquid diet then is indicated for this period and the patient will only be permitted iced water or cold infusions of barley, fruits and prunes, lemonades and water seasoned with vinegar or flavoured with a little mint. Above all these patients must not be given spirits, wine, coffee, tea, very hot beverages or broth. When the fever has abated, toast-water, fruit jellies, etc., may be given. Later the patients will come successively to panades, farinaceous soups, light broth, milk diluted with a great deal of water and then to cold broth with the addition of yolk of egg. But they must not be allowed, even at this stage, vinous liquors and beer, which might bring on vomiting again and increase the restlessness. It is only by very slow degrees that the patients can return to tea or coffee.

In cerebro-spinal meningitis the same regimen is admissible. If feeding by the stomach continues to provoke vomiting, injections of peptons, skimmed peptonized milk, etc., should be resorted to.

Acute Affections of the Alimentary Canal.—In acute febrile gastritis (gastric embarrassment, synocha, fever and catarrhal fever) the appetite almost disappears. Fresh acidulated drinks agree with these patients; tea, meat or vegetable broths generally suit them also. When the fever abates, light foods may be given, a little fish, roast meat, a few vegetables, fruit, boiled eggs and a very small quantity of white wine.

In cases of acute gastro-enteritis with fever, especially if there be vomiting and diarrhœa, and even with young children, the temporary suppression of all food is necessary. For twenty-four to forty-eight hours a little ice only should be permitted which should be left to melt in the mouth, a mixture of iced water with about one-twentieth of slightly sweetened coffee taken in small doses at a time. Later the patient may be given, with discretion, barley water acidulated with lemon juice and slightly sweetened, vegetable broths, albuminous water, toast water and later light farinaceous soups, milk diluted with water, taken almost cold and not boiled, and last of all, raw scraped meat. So long as the acute febrile condition persists, solid foods must not be taken, or those which leave any noticeable residue such as meat or

vegetables, whatever they may be, even as a purée ; they would stimulate the gastro-intestinal peristalsis too much.

At the commencement of gastro-enteritis, broth and milk should also be avoided : the first because it provokes contraction of the intestines and irritates the stomach ; the second because it is in many cases difficult to digest, especially by reason of its fats and because it may thus increase the diarrhœa and nausea.

If the vomiting continues, the stomach should be given complete rest, only a little iced water being taken from time to time, with nutritious injections of peptons and peptonized milk, etc.

We shall say a few words here concerning dysentery, although it is rarely febrile.

In the acute stage of this malady, an almost absolute milk diet must be observed when it is well supported. The patient may be given skimmed or sterilized milk, boiled and tepid, mixed or not according to the case, with a little lime water or subnitrate of bismuth. This milk (from 2 to 2·5 litres per day) should be taken in measures of 150 to 250 cc. at intervals of three hours, at least, in small coffeespoonfuls or through a straw ; in a word, it should be swallowed slowly and never a glassful at a time. If necessary, if this food cannot be supported at all, the milk may be replaced by herb broths mixed with a little flour or rice (not oats), rice water, albuminous water slightly sweetened, egg and milk. Fresh scraped mutton or horseflesh and skimmed milk diluted with water or a little tea constitute a system of feeding which is generally well supported when it is given according to the rules that I have so often set forth. It maintains the often greatly weakened forces of these invalids. It is especially necessary to avoid *cold*, *iced* or *alcoholic* drinks, broth, aerated waters and condiments which favour intestinal peristaltism. Strong coffee, in very small quantities, may be prescribed if the heart has need of a tonic.

Later, if there is no fever and the diarrhœa is diminishing, the patient may return to soups, creams, paps, decoctions of cocoa, lentils and green peas, to boiled fish and especially raw scraped meat, etc.

In *acute peritonitis* the very low diet is indispensable, at least at the beginning. Only ice, iced water or cold water, very slightly sweetened and alcoholized, must be allowed. But tea, coffee, seltzer water, alkaline waters, acid drinks, meat broths, hot or cold, should be forbidden. When the fever abates, only foods leaving scarcely any residue should be prescribed : rice water, toast water or albuminous water, herb broths, very light farinaceous soups (without milk or butter) of sago, alimentary caseins and cooked and grated cheese. Eventually milk may be taken and yolk of egg mixed with a little thin broth, also biscuits, panades, etc.

In chronic peritonitis broth, jellies, grated meat may be given and even, in very small quantities, skimmed milk and a little Spanish wine or old Burgundy.

Intestinal troubles of *appendicitis* should be treated in the same manner as we have just described for acute peritonitis. A diet of solid foods, sugar and water, mixed or not with a very little milk, toast water, light starchy soups, etc., constitute the regimen in these cases, when the intestines should above all be guarde against irritation, and irritable conditions allayed even by opiates.

In *typhoid* fever, an absolute low diet is not suitable; in spite of the temperature, and intestinal ulcerations, the patient must be fed in moderation with skimmed milk, oatmeal or sago soups, meat jellies, broth either pure or mixed with well prepared peptons; wine, or even champagne cognac, tea and coffee, especially if there is prostration, tremblings, stupor, adynamia, if the fever has lasted long and if the heart is growing weak. Alcohol should not be taken in cases of intense cephalalgia, acute delirium, extreme dryness of the skin or albuminuria (Murchisson). Alcoholic drinks are contra-indicated in the case of children, if there is high temperature or much cephalalgia.

In this long illness, ptisans with sugar and even glycerines and decoctions of cereals do good service. The juices of different fruits (apples, peaches, pears, currants, etc.) may be added to them, also fresh meat juice obtained by strong pressure (see p. 140), meat jellies and when possible skimmed milk, pure or diluted with alkaline waters. Milk is both diuretic and disinfecting. Unfortunately it is very rarely supported, at least in the pure state; it often provokes tympanites, colic and vomiting. It must besides be always given skimmed with the addition of a little cognac, rum, coffee, and a few drops of cherry-laurel water, etc.

The diuretic ptisans, weak tea, aqueous drinks of fruit juices (apples, orange, lemon, cherries, currants) with the addition of a little coffee, which sustains the heart, should only be taken in small quantities at a time, but frequently. Care must be taken, indeed, not to distend the stomach and increase dyspnœa. With these precautions, 2 litres per day may be given of it. If there is vomiting, lemonades and aerated waters should be resorted to. Of all these drinks pure fresh water, as a rule, suits the patient best. Diarrhœa can be contended with by mucilage water, rice or quince water.

In the sudorific, renal, hæmorrhagic or hematuric forms, skimmed milk is most particularly recommended.

Since the time of Brown and Graves, English doctors have fed fever patients, and particularly typhus patients. Trousseau, Aran, Behier, Piorry and Lorrain advised this method, and the

recent trials made in France (Vaquez), Germany (Bauer and Küntsley, Puritz), Russia (Gournitzki, Botkin) to give typhoid patients a more solid nourishment, even with milk (half a cup every two hours), appear to have generally succeeded. Rice broth, broth with the addition of a little grated cheese, casein, yolk of egg or Malaga, soups, meat jelly and even (though in very small quantity) little balls of raw scraped meat or meat very lightly broiled, finally, and in a general way, all foods which are easy to digest and which leave very little intestinal residue (milk, oysters, lean fish cooked in water), all taken in small quantities at a time, in such a way as not to cause diarrhœa, may suit these invalids from the time their temperature falls and oscillates in the neighbourhood of 38°.

Albuminoid foods are well digested by these invalids. It has been seen that with them eggs or meat do not produce albuminuria. They often cause diarrhœa to stop. Fever is not increased by them. Out of eleven patients thus treated, Vaquez has never had a case of hæmorrhage [1].

Naturally it is necessary here especially to avoid all excess of foods; the temperature becomes higher as soon as the diarrhœa increases. When there is indigestion and relapse, a stricter diet must be reverted to.

When there is loss of blood by the intestines, the patient should abstain from food and be given only cold drinks, iced ptisans of rice, barley, lemon, at the very most toast water or albuminous water. If it is absolutely necessary to sustain him, it must be by means of nutritious injections; if the heart becomes weak, injections of artificial serum and of caffeine should be resorted to.

Later, the patient may return to soups of flour, creams of rice or sago, to jellies, milk and even raw meat and boiled eggs, etc., but all foods which leave notable quantities of solid residue, such as ordinary meat and herbaceous vegetables, should be as much as possible set aside.

It is in the adynamic states or during convalescence from this serious illness that wine, and particularly good old wines of Burgundy, Bordeaux and Roussillon, especially the red wines, may render great service. Red wine acts at once by its alcohol, its tannin and its tonic colouring matters, by its organic iron which allows of the reglobulization of the blood and by its perfumes which revive the stomach. But whether white or red, wine should only be allowed in small spoonfuls at a time, diluted or not with water, sweetened or not, and always at the end of a light meal or after a little milk.

The premonitory troubles of *cholera* are advantageously

[1] Vaquez, *Alimentation dans la typhoïde*, Presse Médicale, Paris, 1900.

combated from the diuretic standpoint by drinks acidulated with hydrochloric acid (medicinal acid 6 grms., water 1 litre) or with lactic acid (6 grms. per litre) mixed with a little cognac and sugar, or by allowing small pieces of ice to melt in the mouth in case of any tendency to vomiting. As foods, a little flour of rice soup, albuminous water, etc. If the illness progressed and if the collapse were becoming accentuated, hot wine, grogs, lemonade with the addition of rum and vanilla, coffee slightly sweetened and mixed with cognac, etc., would be particularly indicated. In cases of anuria, these last beverages should be insisted on, and if need be, injections of artificial serum should be given. After the crisis a return may be made to a more solid diet by adhering to the above rules and treating the patient in the manner described for convalescence after serious fevers.

Acute Nephritis, Acute Cystitis.—Concerning *acute nephritis* we must remember the injunctions that we gave à propos of chronic nephritis (p. 439). They must be applied here even more strictly. The patient must be kept severely at rest and on milk diet, he must avoid all meat extracts and meat itself so long as the acute stage lasts ; he must be limited to adding to the milk, deprived of its butter or not, a little bread or barley or oat flour ; all spices, coffee and fermented liquors must be avoided.

During acute cystitis the same regimen must be followed ; the patient must drink abundantly of pure water, toast water, barley water, decoctions of fruits or cereals diluted and slightly perfumed, milk mixed with water.

Eruptive Fevers.—They do not give an opening for special indications from the point of view of diet. One must be guided here by general principles, the signs given by the invalid, the intensity of the fever, the state of the heart. Except during the acute febrile stage in scarlet fever, the patient should eat if he is hungry. In measles especially, and in spite of the fever, the patient may be fed with broth, panades, with or without yolk of egg and meat juice. As drinks, lemonades, different infusions taken tepid, wine and water. If it were necessary to revive the strength, tea, coffee and even a little cognac should be given. In scarlet fever, on the contrary, by reason of the possible complication of nephritis, it is well during the whole of the acute stage to limit the invalid to aqueous acidulated drinks, to decoctions of cereals, to skimmed milk diluted with a great deal of water. But in this illness, whatever be the stage at which it has arrived, the kidneys must be relieved ; to do this, broth and meat extracts or juice, which bring their leucomains and other nitrogenous waste matters, must be avoided. Likewise alcohol, highly seasoned and salted dishes must be forbidden to these sick persons ; a milk diet must be insisted on,

and the rules of alimentation applied that we have given for nephritis (p. 439).

Patients attacked with *exanthematic typhus* should, according to Graves, be fed from the third or fourth day with milk, gruels, rice, broth, tea, coffee, wine, grogs if they can support alcohol. The drinks should be abundant, acidulated or slightly alcoholic. Phosphoric acid (10 to 15 grms. of medicinal acid for 300 or 500 grms. of beverage) has been recommended.

In many infectious febrile diseases, one should take into account these last observations founded on the condition of the congested kidneys which are threatened with inflammation and degeneration and irritated by the poison which they excrete.

The same applies when, during the course of these fevers, the intestine is inflamed or rather attacked with specific eruptions and ulcerations, as in small-pox. It is advisable in these cases to feed the patient entirely on milk, panades, jellies, starchy soups and, if necessary, to confine the diet to ptisans of cereals with the help of opiates.

Puerperal Fever, Septicemia, Erysipelas, Diphtheria.—In *puerperal fever,* as soon as it is possible, the patient's strength must be sustained by broth taken tepid, with or without yolk of egg, but above all and from the beginning by alcoholic beverages, iced champagne, meat juice, café au lait and coffee. If there is peritonitis, the patient should be fed in the way given, while speaking of this malady.

This is also the regimen for septicemia, yellow fever, plague, and erysipelas, disorders in which it is necessary to take into account gastro-intestinal complications (see Typhoid fever, p. 501), and at the same time to sustain the patient's strength by diffusible stimulants such as broth, meat juice, alcohol, tonics of every kind, accompanied by abundant acidulated drinks.

In erysipelas, where the kidneys may be altered by the elimination of the toxins, milk diet is indicated, especially if there is any fever. In adynamic forms white wine, coffee, and tonic alimentation (see Tuberculosis, pp. 469, 497) may be necessary, but the kidneys must always be watched from the standpoint of albuminuria.

During diphtheria, especially in grave forms, the patient must be sustained by coffee, alcoholic wines, diluted and sweetened cognac. Even children from three to four years old may be given 4 to 6 grms. of cognac mixed with two parts of sweetened water four times a day. Diphtheric patients require an alimentation as rich as possible, and if necessary their appetite should be stimulated by bitters. Milk is often proscribed in this case, as it may whiten the tongue and the throat and prevent the false membranes from being clearly distinguished. But

to-day, especially in cases of serotherapy, we must not reject milk which is an excellent diuretic, and can besides be diluted with tea, coffee and white wine mixed with water. As other foods, there are cream, meat juices and eggs, except if albuminuria is present, in which case we must return to milk diet and to white wine mixed with water.

Intermittent and Remittent Fevers.—In intermittent fevers the patient should be fed in the best way possible. During apyrexia, his regimen ought to be that of anæmic subjects. This is a case when it is especially necessary to prescribe strengthening foods such as meat and tonics like coffee and generous wines, which the stomach of malarial patients generally manages to support very well.

In *remittent fevers* the patient, as in *hectic* fever, must be fed, especially at the time when the temperature oscillates. As in the preceding case, the foods which best suit their taste are above all tonic substances such as meat juice obtained by pressure, underdone meat, eggs, fish, milk, small quantities of cognac, Bordeaux and Burgundy wine, etc.

XLVII

DIET OF CONVALESCENTS AND OF SURGICAL CASES—LOSS AND RECOVERY OF MINERALS IN THE TISSUES OF THE ORGANISM

THE diet of convalescents and of those who have undergone operations should provide the tissues not only with the organic principles which they lack, but also with the mineral materials necessary to their reconstitution. So we shall treat in the same chapter about the diet of convalescence and about the methods of restoring minerals to the organism.

DIET OF CONVALESCENTS AND OF SURGICAL CASES.

Diet of Convalescents.—The losses incurred by the organism in the course of febrile ailments may be enormous, especially among children and young people. They affect at the same time the nitrogenous, the ternary and the saline principles. The invalid reduced by abstinence or fever has then great need of food. But it must be given with prudence: convalescents often suffer from a dyspeptic condition or from a stomachic erethism which prevents their being well fed; the intestines may remain irritable and the nerve centres only receive with an extreme morbid over-excitability the impression of a fresh regimen.

In the course of the febrile period, the invalids have first lost their fats, at the same time and in a less degree, they have become poor in albuminoid principles and mineral salts. The aim is to restore all the tissues in the quickest and best way possible.

As to the fats, we know that they are easily recuperated by means of the alimentary carbohydrates. No need, in consequence, to insist on making convalescents take butter and other fatty foods which they would not always digest. Light soups of oatmeal, rice flour, rice, tapioca or the juice of fruits; milk foods and creams made from a mixture of yolk of eggs, milk and flour of cereals; honey, sweetened jams, very ripe fruits, particularly grapes, etc., enable us to introduce into the system sufficient carbo-hydrates easily assimilable to renew the lost fats.

As far as proteids are concerned they must only be allowed with reserve for fear of indigestion. They do not always assimilate easily, and fairly small quantities are sufficient for convales-

cents. Milk, eggs, grated ham given in small quantities at a time, some purées of seed or green vegetables and bread provide ample fare. In general, 50 to 60 grms. daily of proteid substances, that is to say nearly half the albuminoids of the alimentary allowance of a healthy man, are a maximum.

The convalescent must be fed by small meals only, every four hours for example, in order to try the stomach without ever overloading it. Salad, cabbage, mushrooms, acid, tough or oily fruits, spiced condiments, high game, pork, too fat fish, crustacea and chocolate must be forbidden.[1]

Milk is, par excellence, the food of convalescents ; if they cannot take it (which is rare) it is necessary to endeavour to make them tolerate it, sweetened or salted, or with the addition of a little cognac, kirschwasser, cherry-laurel or orange flower water, coffee, tea, and cocoa partially freed from its fat. Milk may be raw or cooked, mixed or not with water, lime water, Vichy, etc. When it has been freed from butter by churning and sterilized, it is an excellent food for convalescents.

With or after milk soups, panades, semolinas, biscuits, meals and the farinaceous preparations which are manufactured in so many forms, vegetable purées and fish cooked in salted water, may be allowed. This fish (sole, dab, whiting, turbot) is rich in albuminoids and phosphorus and easily digested. Sprinkled with a little lemon, it is generally much more agreeable to convalescents than ordinary meat, above all beef, veal or pork, which are more difficult to digest and which leave in the intestine more toxic compounds (E. Cassaet). The flesh of boiled fowl is also very easy of digestion. Grated raw meat, swallowed without being masticated, is still more so ; but it may be disagreeable to convalescents.

Mineral salts are the third kind of food indispensable to convalescents. Phosphates, above all the salts of potash, have been lost in the course of the illness and often in very large quantities ; the deglobulization has attacked the hæmatogenous elements and caused the disappearance of these salts the elimination of which is, according to Salkowski, three to four times more energetic during fever than in the normal state ; lime and magnesia are at the same time passed in the urine without the incomplete recovery of the patient having been able to restore them. It is necessary then for convalescents, especially those who have been on low diet for a long time, for children and youths, as well as for every invalid who has undergone hæmorrhage, to have a diet which will replace minerals liberally.

One of the most efficacious foods for this purpose, after milk,

[1] Pure chocolate, especially boiled in water, is very indigestible ; cocoa, when its fat has been removed, is less so.

is meat broth which brings with it the salts of the muscular tissue, that is to say of the tissue, the mass of which is much the most preponderant. Broth is particularly rich in phosphates of potash and in salts of magnesia. If need be, casein powder may be added : this also provides its contingent of phosphorus and lime. Bread, milk and vegetable purées especially, furnish the means of introducing into the system mineral substances, particularly phosphorus, in the most assimilable forms. We know that it is found in cereals and bread and especially in vegetables in the form of phytin, an oxymethylenophosphoric combination. Introduced directly into the system, the salts of this organic phosphoric acid seem to have given excellent results compared with the other phosphorous compounds and in particular with mineral phosphates (see p. 333).

Finally, in order to hasten remineralization, liquids or artificial powders of a composition analogous to that of the ashes of the blood and containing in the same relations as these chlorides phosphates, carbonates . . . of potash, soda, lime, magnesia may be resorted to. We shall return to these farther on (p. 511).

Remineralizing drinks are also very useful. The best are decoctions of cereals (oats, barley, flour of wheat, etc.) accompanied by a little old red Bordeaux wine which acts as a light and organic ferruginous tonic. Later on Burgundy or light beer may be allowed, in small quantities at a time.

Together with small quantities of these stimulants, some spices, like salt, vinegar and bitters may be allowed when it is necessary to stimulate the intestinal functions and the appetite.

Diet after Operations.—This diet resembles that of convalescents, but with some variations having their importance.

The patient who is to undergo a surgical operation ought to have his stomach free from food for six or eight hours at least, and in consequence not to have eaten anything for eight or twelve hours, the action of chloroform generally provoking, during the twenty-four to forty-eight hours following the operation, a condition of nausea, and sometimes vomiting which it is necessary to guard against. After the operation, the patient should be given by spoonfuls, iced water mixed or not with a very small quantity of coffee, and later on a little broth and even wine. This diet is sufficient for the first twenty-four hours. Afterwards purées, panades, or other semi-liquid foods very easily digested may be given, and towards the third day, milk foods and the feeding of convalescents previously described.

If the operation took place in the stomach, it would be necessary to give opium to take away the appetite, and only to feed the patient by the rectum for three or four days. We shall return to this (p. 527). It is possible afterwards to return

to direct feeding, on the fifth or sixth day with soups, flours, milk, etc., all in small quantities at a time.

The same precautions ought to be taken after operations on the intestine. Raw grated meat, milk, paps, eggs may be administered from the fourth or fifth day.

Diet to Restore Minerals.

Mineral starvation is produced in convalescence from nearly all acute and in many chronic illnesses, more particularly in pulmonary phthisis, in many cases of anæmia with or without chlorosis, in certain forms of hæmoglobinuria, dyspepsia, diabetes, azoturia, etc. It exists to a more or less marked degree in all invalids.

We know that the system deprived of salts only protects itself with difficulty against the action of toxins; a dog fed on meat exhausted beforehand of mineral substances, dies more rapidly than one which has been put on extreme low diet (Forster). We know also that the muscular, and especially the nervous tissues, have need principally of phosphorus, potash and magnesia to restore themselves, that the red corpuscles disappear or no longer reproduce themselves if the plasmas are impoverished in alkaline salts; that the elimination of the toxic nitrogenous materials is assured by the salts of soda; finally that the intra-cellular oxidations can only be accomplished in the midst of alkaline plasmas.

Whilst it exhausts the plasmas of mineral salts, the illness enriches the urine with them, temporarily at least, and it is possible, by the study of the blood and renal secretion, to have the proof of these two continuous actions which measure the demineralization.

It is indeed characterized, on the one hand, by the impoverishment of the blood plasma in mineral salts, and by the enrichment of the urine in organic products on the other. M. A. Robin gives the name of *coefficient of urinary demineralization* to the relation existing between the mineral principles and the total residue of the urine. This relation varies in the normal state from 29 to 32 per cent. Its general average is 30, that is to say that in a state of health, for 100 parts of dry urinary residue 30 parts are formed by mineral salts. But among invalids who are being demineralized, 50 per cent. and more of the urinary residue may be formed by mixed salts. In the same way, the proportion of the inorganic salts of the blood to the total residue, is in the normal state 5 per cent.; but, if there is demineralization of the organism this proportion may be lowered to 3 per cent. and even less.

Here is, taken from a female patient, an example of anæmia by demineralization of the humours; I borrow it from the same author:—

Per Litre.	Demineralized Blood.	Normal Blood.
Density	1·040	—
Total residue	191·2	—
Organic residue	186	—
Mineral residue	5·6%	9%
Ratio $\frac{\text{mineral residue}}{\text{total residue}}$	2·91%	5%

The urine presented the following characteristics :—

	Urine of Demineralization per 24 hours.	Per kilogrm. of Body Weight.	Normal Urine per kilogrm. of Body Weight.
Density	1·017 grms.	—	1·018 grms.
Total residue (per litre)	36·6 ,,	0·852 grms.	0·810 ,,
Organic ,, ,, ,,	18·8 ,,	0·458 ,,	0·605 ,,
Mineral ,, ,, ,,	17·8 ,,	0·414 ,,	0·289 ,,
Ratio $\frac{\text{mineral matter}}{\text{total residue}}$ =	48·5%	48·5%	31%
Ratio $\frac{P^2O^5}{\text{total nitrogen}}$ =	—	—	8·5%
Nitrogen eliminated (per litre)	—	0·288 ,,	0·161 ,,
Nitrogen eliminated (per kgrm.)		0·240 ,,	0·146 ,,

The coefficient of urinary demineralization which rises here to 48·5 per cent. would be enough to well characterize, in the case which we are analysing, the state of active impoverishment of the organism in mineral salts. In the course of some diseases, this coefficient rises remarkably above the normal, which is 31 per cent. : in *tuberculosis*, for example, it rises to 45 and 46 per cent. at the beginning, then falls to 38 and 35 per cent., and only returns to 30 per cent. when, having reached the third period of the disease, the organism is almost exhausted of all its reserves of salts. In hæmoglobinuria, whatever be the cause or effect, demineralization still expresses itself by high coefficients reaching 43 per cent. In certain varieties of dyspepsia with hyperchlorhydria, the coefficient of demineralization also increases, and may be maintained much above the normal even when hypochlorhydria succeeds to the first state. Scurvy is again a malady of demineralization or perhaps of *non-mineralization* for want of vegetable salts, of potash in particular.

The demineralization of the plasmas acts necessarily on the anatomic elements which the salts are charged with preserving and nourishing. In a demineralized blood plasma, the globules of the blood alter. In the midst of a tissue irrigated by demineralized blood, organic anæmia, deglobulization, anærobic cellular destruction, succeed mineral anæmia and are the consequence of it. Hence hæmorrhages, methemoglobinuria, discharges of

uric acid and toxins, diminution of the oxidations and particularly the lowering of the coëfficient of oxidation of sulphur and of weight of urea in the twenty-four hours, which is observable in these cases.

How can we remineralize the organism ? Evidently first by combating the causes of demineralization, hyperchlorhydria, dyspepsia, leucocytosis, anæmia, phosphorism, etc., on the other hand, by providing the organism abundantly with the salts in which it is lacking. These may reach the invalid by means of foods or medicaments.

In order to choose between these two ways, it is necessary to take the state of the stomach into consideration : if it can digest vegetables, fresh or dry, bread, milk or wine, these will suffice at need to furnish the invalid with the quantity of salts of potash, lime, magnesia, phosphoric acid, etc., which he lacks.

In the contrary case, medical treatment should be resorted to first, and the same salts given to the patient by the stomach in the form of powders or solutions, for the hypodermic method has numerous inconveniences. It does not allow the mineral elements to be *organified* in passing through the alimentary canal, that is to say, to take, whilst combining with the nitrogenous or ternary matter in process of digestion, the form which is most suitable to their rapid assimilation.

Phosphorus in the state of phosphates, of glycerophosphates, of lecithins and phytine may be given by the stomach or in the digestible forms which it possesses in certain foods : yolks of eggs, seeds of vegetables, bread, fish, crustacea, brains, etc., foods rich in phosphorated organic products very readily assimilable.

Amongst the best remineralizing agents, we should mention decoctions of the flour of cereals (barley, wheat, oats) rich in organic phosphorus and in salts of potash and magnesia as has already been shown.

We may also make use of the mineralizing powder formulated by A. Robin, a complex powder to which he has given the significant name of *thériaque minérale* and which he compounds as follows :—

	grms.		grms.
Salt	15	Hæmoglobin in powder	2·50
Chloride of potash	10	Glycerophosphate of iron	15
Phosphate of soda	13	Yolk of egg dry	15
,, ,, potash	6	Lactose	10
Fluoride of sodium	1	Casein	5
Glycerophosphate of lime	}	Powder of St. Ignatius bean	1
,, ,, magnesia	} āā 1	,, ,, rhubarb	4
Sulphate of potash	}		

In this mixture, at once medicinal and alimentary, each element plays its special rôle. The fluoride of sodium (1 to 2 centigrms. per day) is added with the object of preventing in the stomach

faulty digestion and bacterial fermentation. Two to three grms. daily may be taken of the powder.

When anæmia continues for a long time and the red blood corpuscles increase slowly, a supplement of salts of iron is of great advantage either in the form of oxalate or of ferro-potassic tartrate or of hæmatogen so abundant in the young leaves of edible vegetables such as spinach, salads, etc., or in the state in which the iron is found in the tonic wines of Bordeaux, Burgundy, Roussillon or Spain. The small proportion of mineral or organic arsenic of foods may also play its part.

In the case of the invalid of A. Robin, who was anæmic from demineralization, and which we have just quoted (p. 510), the remineralizing cure which we have described was confirmed, after treatment, by the following results :—

	State of the Urine,		State of the Blood. Per litre.	
	Per 24 Hours.	Per kilogrm of Body Weight.		
Density of the urine .	1·009	—	Density	1·050
	grms.	grms.		grms.
Total residue . . .	41·25	0·993	Solid residue per litre	204
Organic ,, . .	19	0·632	Organic residue . .	195·5
Mineral ,, . .	16·25	0·361	Mineral ,, . .	8·85
Ratio : $\frac{\text{mineral matter}}{\text{total residue}}$	35·59%	35·59%	Ratio : $\frac{\text{mineral salts}}{\text{total residue}}$	4·33%
NaCl eliminated . .	11·26	0·247		
Ratio : $\frac{P^2O^5}{\text{total nitrogen}}$	7·9%	7·9%		
Eliminated nitrogen .	—	0·146		

After the remineralizing treatment, the aggregate of exchanges had become normal (0·994 grm. per kilogramme of body weight) ; the organic matters eliminated had passed from 0·438 grm. to 0·632 grm. per kilogramme of body weight, whilst the *mineral matters were diminishing*, passing from 0·414 grm. to 0·361 grm. per kilogramme. The blood was enriched at the same time in organic and in mineral principles, but the latter had progressed more than the former and the ratio $\frac{\text{mineral salts}}{\text{total residue}}$ had risen, for the blood, from 2·91 to 4·33 per cent., that is to say, the mineral matters of the blood plasma had increased more than one half.

XLVIII

ALIMENTATION IN HOSPITALS, ASYLUMS AND PRISONS IN FRANCE

WE cannot in this work omit to treat of alimentation in asylums and hospitals, though not, as we have just done in the preceding chapters, by considering the diet which suits each complaint and each separate case, but by regarding it this time from the standpoint of the whole of the inmates of the hospitals, acute or chronic patients, old people, aided people, infirm people, invalids or healthy people of every sort, attached to these institutions.

To the general study of alimentation in hospitals, we will add a few facts concerning alimentation in prisons ; the sick person lives a little after the manner of a prisoner and the latter is very often ill. It would not be possible to entirely separate the study of their respective regimens.

Alimentation in the Hospitals.

First of all two important remarks must be made here : On the one hand the sick person, either from want of appetite or lack of exercise or exaggerated impressionability, is more difficult to feed with common or badly prepared dishes than the healthy man outside the hospital with a strong stomach strengthened by the open air and by sufficient physical exercise. The sick person requires then, if not choice dishes, at least foods of good quality. On the other hand, wounded people, convalescents, and especially during the first weeks, a man of the lower classes attacked with a chronic disease who, when made to rest, is benefited by a regimen often more healthy than his usual regimen, generally eats more than in the normal state, and at first gains very sensibly in weight at the hospital. It is necessary then that in the case of the hospital patient who has no fever, the quantities of food allotted should be at least equal to those of a healthy man of the same weight. It may be admitted that these foods ought to furnish those who receive the entire ration (4*th degree* or *four*

portions of the Paris hospitals) with a regimen corresponding to the following numbers of Calories :—

	For a Weight of Body of		
	50 kgs.	60 kgs.	70 kgs.
Men . . .	—	2,300 Cals.	2,500 Cals.
Women . . .	1,900 Cals.	2,100 „	—

Except for women during confinement and wet nurses, a woman requires about one-fifth less food than a man of the same age. On the contrary, we have seen that, for the same weight, children should be fed with twice as much as adults. A boy weighing 30 kgrms. should receive as much food as a grown man of 60 kgrms.

Alimentation of Hospital Patients.—According to the *Regulation* of 1867 on *the alimentary regimen of the hospitals of Paris*, a regulation called after Husson [1] which has since remained in force, sick people may be subjected, according to the daily prescriptions of the physician, to the following four modes of alimentation : (*a*) *absolute diet ;* (*b*) *simple broth diet ;* (*c*) *soup alimentation ;* (*d*) *solid alimentation.*

(*a*) *Absolute diet.*—Patients undergoing this regimen receive only non-alimentary liquids and ptisans.

(*b*) *Simple broth diet.*—In this case patients receive four portions of 25 centilitres each per day (in all 1 litre) of thick broth ; children 800 centilitres.

(*c*) *Patients on soup diet.*—With this regimen adult men receive per twenty-four hours :—

Thick broth	500 cc.
Thick meat soup	600 „
Wine	120 „

We shall see later how this broth and soup are obtained.

(*d*) *Patients on a diet of solid foods.*—In their turn, these invalids, who receive meat and bread, are fed in *four degrees* differing according to their condition from the *first degree*, for those who are fed the least, up to the fourth, which corresponds to the alimentation of convalescents in full course of recovery. The second and third degrees are, however, very rarely used by the doctors. I shall indicate in the following tables for each degree only the quantities of food distributed to men, the corresponding regimen for women being the same, but lessened by a quarter to one-sixth according to the case, and that of children being double that which is necessary for the same weight of an adult. I shall

[1] *Règlement sur le régime alimentaire des hôpitaux et hospices civils de Paris*, 1867 (Husson, rapporteur).

also note in these tables only the weight of *prepared dishes :* it is a fact that roast or boiled meat corresponds to a double weight of raw meat ; that cooked fruits lose a quarter of their weight, fish a third, fresh vegetables a third, after peeling and cooking ; that dry vegetables, on the contrary, increase by half ; that cooked rice increases fivefold in weight by absorbing water. These coefficients will enable us, at will, to pass from the weights indicated above to those of each of the foods before cooking. Seasonings are not included in these tables.

Here is, then, according to the *Règlement administratif* named after M. Husson, the composition of the four regimens of the Parisian hospitals for patients put on 1, 2, 3 and 4 portions.

			Men.	Youths 12–15 yrs. old
A. PATIENTS OF THE 1ST DEGREE (OR PATIENTS ON ONE PORTION).				
a. *For the day*		White bread	120 grms.	90 grms.
		Wine	240 cc.	160 cc.
b. *Petit déjeuner before the doctor's visit.*		Milk	250 ,,	200 ,,
c. *Morning meal*		Meat soup	300 ,,	250 ,,
		Roast meat	60 grms.	40 grms.
d. *Evening meal*	1st	Meat soup	300 cc.	250 cc.
	2nd	Poultry (twice a week)	60 grms.	40 grms.
		or roast meat ,, ,,	60 ,,	60 ,,
		or fish ,, ,,	80 ,,	50 ,,
		or fresh eggs (once a week)	1 egg	1 egg
B. INVALIDS OF THE 2ND DEGREE (OR INVALIDS ON TWO PORTIONS).				
a. *For the day*		White bread	240 grms.	180 grms.
		Wine	240 cc.	160 cc.
b. *Petit déjeuner before the doctor's visit*		vegetable soup	300 cc.	—
		or milk	—	200 cc.
c. *Midday meal*		Vegetable soup	—	250 ,,
	1st	Roast meat (5 times a week)	60 grms.	40 grms.
		or stew (twice a week)	60 ,,	40 ,,
	2nd	Fresh eggs ,, ,,	1 egg	1 egg
		or cooked fruit (once a week)	100 grms.	60 grms.
		or prunes (twice a week)	90 cc.	60 cc.
		or rice in milk (twice a week)	100 grms.	50 grms.
d. *Evening meal*	1st	Meat soup	300 cc.	250 cc.
	2nd	Boiled meat (5 times a week)	60 grms.	40 grms.
		or fish (twice a week)	80 ,,	50 ,,
	3rd	Vegetables in season (5 times a week)	80 cc.	—
		(children, 4 times)	—	50 cc.
		or potatoes in milk (twice a week	120 grms.	80 grms.
		or preserves (once a week)	—	30 grms.

Each soup or stew includes 300 cc. of broth, 30 grms. of bread or 20 grms. of paste for adults ; 250 cc. of broth, 20 grms. of bread or 10 grms. of paste for children.

			Men.	Youths 12–15 yrs. old
C. Invalids of the 3rd Degree (or Invalids on Three Portions).				
a. *For the day*		White bread	360 grms.	270 grms.
		Wine	360 cc.	240 cc.
b. *Petit déjeuner in the morning.*		Vegetable soup	300 ,,	250 ,,
c. *Midday meal*		Vegetable soup	—	250 ,,
	1st	Roast meat (3 times a week) .	60 grms.	40 grms.
		or internal organs (once a week)	80 ,,	50 ,,
		or boiled meat dressed (3 times a week)	60 ,,	40 ,,
	2nd	Vegetables in season (once a week)	120 ,,	80 ,,
		or dry vegetables (5 times a week)	120 ,,	80 ,,
		or eggs cooked (once a week) .	1½ eggs	1 egg
d. *Evening meal*	1st	Meat soup	300 cc.	250 cc.
	2nd	Boiled meat (6 times a week)	90 grms.	60 grms.
		or fish (once a week) . . .	120 ,,	80 ,,
	3rd	Fresh vegetables (3 times a week	120 cc.	88 cc.
		or potatoes (twice a week) . .	180 ,,	120 ,,
		or rice with milk or with meat soup (twice a week)	150 ,,	75 ,,
D. Invalids of the 4th Degree (or Invalids on Four Portions).				
a. *For the day*		White bread	480 grms.	360 grms.
		Wine	480 cc.	240 cc.
b. *Petit déjeuner in the morning.*		Vegetable soup	300 ,,	250 ,,
c. *Midday meal*	1st	Vegetable soup	—	250 ,,
	2nd	Roast meat (3 times a week) .	90 grms.	60 grms.
		or internal organs (once a week)	120 ,,	80 ,,
		or boiled beef dressed (3 times a week)	90 ,,	60 ,,
	3rd	vegetables in season (once a week) or dry vegetables (5 times a week)	160 cc.	100 cc.
			160 grms.	120 grms.
		or cooked eggs (once a week) .	2 eggs	1½ eggs
d. *Evening meal*	1st	Meat soup	300 cc.	250 cc.
	2nd	Boiled meat (6 times a week) .	120 grms.	80 grms.
		or fish (once a week) . . .	160 ,,	100 ,,
	3rd	Fresh vegetables (3 times a week)	160 cc.	100 cc.
		or potatoes (twice a week) . .	240 ,,	160 ,,
		or rice with milk or meat soup (twice a week)	200 ,,	100 ,,

Alimentation of the Healthy, the Infirm, and Old People.—The healthy, the infirm, incurable old people and lunatics receive in our asylums the following quantities of food[1]:—

[1] It will be remembered that these quantities are calculated for *prepared food* and for adult men; that for women there is a difference of a quarter to one-sixth less.

Feeding of Adults (Men) Healthy or Insane in the Asylums of Paris.

			Healthy.	Insane.
a. *For the day*		1st. Bread soup	100 grms.	100 grms.
		2nd. White bread	500 ,,	570 ,,
		3rd. Wine	140 cc.	120 cc.
b. *Déjeuner*		Vegetable broth	500 ,,	500 ,,
		or milk	250 ,,	200 ,,
c. *Dinner*	1st	Dry vegetables	200 ,,	220 ,,
		or fresh vegetables	220 grms.	220 grms.
		or potatoes	330 ,,	330 ,,
		or rice	200 ,,	200 ,,
	2nd	Cheese	40 ,,	40 ,,
		or prunes	150 cc.	150 cc.
		or preserve of pears and quinces	60 grms.	60 grms.
d. *Supper*		1st. Meat broth for soup	450 cc.	450 cc.
		2nd. Boiled meat	120 grms.	140 grms.

Seasonings are not included in these weights in any case.

Alimentation of Pregnant Women and Wet Nurses.—The regimen in the special Parisian hospitals for pregnant women and wet nurses may be, as always, specially modified by order of the doctor, but in ordinary cases it is thus constituted :—

Regimen for Pregnant Women and Wet Nurses.

a. *For the day*		White bread	720 grms.
		Wine	200 cc.
b. *Déjeuner*		Vegetable stock for soup	600 ,,
c. *Dinner*	1st	Meat stock for soup	600 ,,
	2nd	Boiled meat	140 grms.
	3rd	Dry vegetables	360 cc.
		or fresh vegetables	440 ,,
		or potatoes	660 ,,
		or rice	350 ,,
d. *Supper*		Boiled meat with vegetables or condiments	120 grms.

Regimen of Young Children in Charitable Institutions.—To these regimens relating to adults, youths from 12 to 15 years old suffering from acute diseases, infirm people, convalescents, healthy people, pregnant women and wet nurses, we will add the alimentary regimen of young children in our almshouses.

Regimen of Young Children from 2 to 6 Years.

a. *For the day*	Bread for soup	100 grms.
	White bread	300 ,,
	Wine	—
b. *Déjeuner.*	Vegetable stock for soup	300 cc.
c. *Dinner*	1st. Meat stock for soup	300 ,,
	2nd. Boiled meat	70 grms.

d. *Supper*	1st	Dry vegetables	120 cc.
		or fresh vegetables	140 „
		or potatoes	210 „
		or rice	200 „
	2nd	Cheese	40 grms.
		or prunes	12 cc.
		or preserve of pears or quinces	50 grms.

From six to twelve years the regimen of boys and girls is increased by one-third compared with the preceding regimen.

Summary relating to the Regimen of Hospital Inmates.—It being understood that the quantities indicated in the above tables are those of foods *after preparation* and not those of fresh foods, the weights of which are higher in the proportions indicated above (p. 315) it is evident that the alimentation of our hospitals furnishes the patient with an invigorating nourishment in a suitable and quite sufficient form. Indeed, if we calculate in *fresh food* and in corresponding fundamental nutritive principles, the average alimentation of an invalid or convalescent having four portions, who is in circumstances comparable to those of the adult not in hospital, we shall find that he receives per day :—

Foods.		Containing		
		Albumin.	Fats.	Carbo-hydrates.
White bread .	540 grms.	44·8 grms.	5·9 grms.	275·4 grms.
Fresh meat . .	420 „	88·2 „	21·46 „	1·9 „
Green vegetables	170 „	2·4 „	0·51 „	10·2 „
Dry vegetables .	126 „	28·22 „	2·4 „	70·0 „
Butter or oil .	30 „	—	28 „	—
Wine . . .	480 cc.	—	—	78 [1] „
Total . .	—	163·62 grms.	57·36 grms.	435·5 grms.

We see (if the rations distributed to the patients are really those entered in the administrative books) how rich the alimentation is in albuminoids as well as in ternary foods, the weight of which rises, as it should, to nearly four times that of the nitrogenous foods. The alimentation of 4 *portions* in our hospitals is capable of producing 2,900 Calories per day. The quantities of food disposed of by our patients and convalescents of 4 *portions* are then amply sufficient, the maintenance allowance of the healthy man only furnishing him on an average with 2,400 Calories.

To the preceding data, and in order that it may be possible to find here the practical indications necessary to calculate and if need be reproduce the alimentary regimen of our invalids, we

[1] Calculated in corresponding sugar.

will add the following determinations also borrowed from the work of the late Directeur de l'Assistance publique in Paris :—

MEAT BROTHS FOR INVALIDS.

		I. Broth for Invalids with Modified Diet (without solid foods).	II. Broth for Invalids with 1, 2 and 3 portions.	III. Another Formula.
Meat	Beef . . 60 kgs. Pork . . 36 ,, Liver or bone 4 ,,	100 kgs.[1]	100 kgs.	100 kgs.
Salt		3·0 ,,	3·5 ,,	3·6 ,,
Green vegetables		20 ,,	36 ,,	27 ,,
Dry burnt sugar		0·150 ,,	0·180,,	0·200 ,,
Water		240 litres	300 litres	350 litres

Reduce by simmering from a twelfth to a fourteenth.

VEGETABLE SOUPS OF THE PARISIAN HOSPITALS.

	Soup of Dry Vegetables.	Soup of Leeks and Potatoes.	Julienne.
Water . . .	100 litres	100 litres	100 litres
Butter and fat .	2·75 kgs.	2·75 kgs.	3 kgs.
Salt	1·20 ,,	1·20 ,,	1·20 ,,
Pepper . . .	0·005 ,,	0·005 ,,	0·005 ,,
Dry vegetables .	10 litres	0·00 ,,	4 kgs. (carrots, turnips, etc.)
Fresh ,, .	0·00 kgs.	0·00 ,,	4·00 kgs.
Leeks . . .	0·500 ,, (onions)	6.00 ,,	0·00 ,,
Potatoes. . .	0·00 ,,	12·00 ,,	4·00 ,,

To these data we will add, combined in the following table, the composition of the regimens of four portions or maximum regimens of a few French (not Parisian) hospitals, while limiting ourselves to giving here only the figures relating to the alimentation of adult patients of the masculine sex.

REGIMEN OF 4 PORTIONS OF DIFFERENT FRENCH HOSPITALS.

	France Naval.	France Military.	Lyons.	Lille.	Rouen.	Dijon.	Bordeaux.	Marseilles.
Bread. .	750 gms.	750 gms.	500 gms.	310 gms.	480 gms.	500 gms.	600 gms.	450 gms.
Wine . .	230 cc.	250 cc.	400 cc.	0·0	600 cc. (cider)	500 cc.	400 cc.	380 cc.
Meat . .	280 gms.	280 gms.	250 gms.	130 gms.	180 gms.	250 gms.	238 gms.	150gms.
Soup . .	937 cc.	100 cc.	300 cc.	250 cc.	300 cc.	500 cc.	550 cc.	400 cc.
Fresh vegetables.	0·0	0·0	300 cc.	250 cc.	240 cc.	250 cc.	0·00	120 cc.
Dry do. .	250 cc.	250 cc.	300 cc.	100 cc.	240 cc.	150 cc.	0·00	750 cc.
Milk . .	0·0	0·0	0·0	200 cc.	0·0	500 cc.	200 cc.	125 cc.

[1] In the case of patients on low diet the broth is made of meat without internal organs, and not including bone.

We see the great difference which exists between the regimens of the hospitals in the various parts of the country, as bread, meat, wine, milk, etc.

It is almost useless to again repeat that, in every case, the doctor may modify or increase by special prescriptions his patient's alimentation by means of an entry in his visiting book.[1]

Let us see by way of comparison how the feeding of invalids is managed in foreign hospitals.

At the Charity Hospital in Berlin, there are five kinds of regimens. We borrow details from Ewald (*Die naturwissenschaftlichen und medicin. Staatsanstalten*, Berlin, 1886, p. 354).

[1] The French physicians, and especially the *Société médicale des hôpitaux de Paris*, have formulated some objections to the regulation of the regimen of sick persons called after Husson which we have just set forth. They object that the second and third degrees complicate their prescriptions and are never, so to say, used in practice ; that boiled meats and meat soup predominate too much in the alimentation of invalids thus understood ; that partial or entire milk diet is only exceptionally provided and remains insufficient ; that the same applies to eggs which are only digested with difficulty ; and that on the contrary wine appears to be granted too abundantly. Their chief objection is that, in this regulation, the degrees of alimentation are founded rather on the quantities of foods than on their nature ; that it is advisable, however, in regulating the hospital rations of the patients to let the foods play a large part. Consequently, through the agency of their Secretary, M. A. Chauffard, the doctors of the Parisian hospitals propose to provide and inscribe in the visiting books the following seven special alimentary regimens :

A. *Mixed or normal diet.* For healthy subjects, hospital servants or crippled inmates, tabetics at the beginning, secondary syphilitic persons, mad people, etc. B. *Diet of convalescents.* C. *Diet of superfeeding.* D *Diet of diabetics.* E. *Diet of dyspeptics.* F. *Milk-vegetarian diet.* G. *Whole milk diet.*

Here is the composition of each of these seven kinds of diet :—

A. Mixed or Normal Diet.—*Meal before the doctor's visit.*—Soup with milk or vegetables, 300 cc. or café au lait, 300 cc. *Morning meal.*—Roast meat, 100 grms. or minced internal organs, 100 grms. Dry vegetables, 150 grms., vegetables in season, 130 grms. with the addition of 1 egg. *Evening meal.*—Meat or vegetable soup, 300 cc. Fish, 160 grms. or roast meat (or boiled meat dressed), 100 grms. Potatoes, 240 grms. Fresh vegetables, 160 grms., or rice in meat soup or in milk, 200 cc. or paste. Bread at discretion. Wine : men, 300 cc. ; women, 250 cc. (or milk, 1 litre) ; or beer or cider 1 litre.

B. Diet of Convalescents.—*Meal before the doctor's visit.*—Milk or café au lait, or milk porridge or broth, 300 cc. *Morning meal.*—Cutlet, or one-sixth of roast chicken. Purée of potatoes or dry vegetables, 150 cc. *Evening meal.*—Milk soup or broth, 300 cc. Lean fish, 160 grms. or 2 eggs or brains. Cooked fruits or a compote, rice milk. Milk, 1 litre, wine, 200 cc. Bread at discretion.

C. Diet of Dyspeptics.—*Meal before the doctor's visit.*—Soup with milk, 300 cc. *Morning meal.*—Roast meat, pounded or not, 100 grms. Purée of green vegetables or feculents, 150 grms., or alimentary pastes, 120 grms., or 2 eggs. *Evening meal.*—The same composition with the addition of 300 cc. of milk soup or vegetable soup. Milk $1\frac{1}{2}$ litres.

D. Milk-Vegetarian Diet.—Two litres of milk, 4 eggs, 2 milk

Regimens I and II which follow, apply to fever patients; regimens III, IV and V are for non-fever patients and convalescents :—

REGIMEN OF FEVER PATIENTS (CHARITY HOSPITAL OF BERLIN)

	I.	II.
Morning. Café au lait	500 cc.	500 cc.
Midday. Broth	250 „	500 „
Afternoon. Café au lait	500 „	500 „
Evening. Flour or milk soup . . .	250 „	500 „
Besides for the day White bread	80 grms.	250 grms.

REGIMEN OF NON-FEVER PATIENTS (CHARITY HOSPITAL OF BERLIN)

		III.	IV.	V.
Morning.	Café au lait	500 cc.	500 cc.	500 cc.
Midday	Broth	500 „	0·00 cc.	0·00 cc.
	Cooked vegetables . .	500 cc.	500 cc.	1000 cc.
	Meat	167 grms.	167 grms.	167 grms.
Afternoon.	Café au lait	500 cc.	500 cc.	500 cc.
Evening.	Soup	500 „	500 „	1000 „
Besides for the day	White or coarse bread .	250 grms.	375 grms.[1]	500 grms.[1]

[1] Coarse bread.

soups.—The two eggs may be replaced by 100 cc. of cooked green vegetables, or 150 cc. of purées of feculents, or 120 grms. of alimentary pastes.

E. WHOLE MILK DIET.—Men, 3½ litres of milk.—Women, 3 litres.

F. DIET OF SUPERFEEDING.—It would comprise one of the above fundamental regimens with a supplement consisting of 2 eggs, or sardines in oil, or 100 to 150 grms. of raw pulped meat, or cheese and butter.

G. DIET OF DIABETICS.—Kind of food appropriate to this condition, but the quantity varying essentially in each case.

Whatever be the diet adopted, the doctor will keep the power of resorting, by means of the special vouchers signed by him, to such a modification or special supplement as appears to him useful.

For children, on the Report of Dr. Sevestre, the Commission has requested per day:—

A. FOR INFANTS AT THE BREAST.—Sterilized natural milk, 1 litre.

B. WEANED INFANTS.—1½ litres of milk; 50 grms. of flour for pap; 25 grms. of sugar; 1 egg.

C. SMALL CHILDREN.—½ litre of milk.—*In the morning*—Milk soup, vegetable soup, or chocolate twice a week. 2 eggs, or fish, chicken, roast meat, 80 grms. Purée of vegetables 80 grms., or potatoes, or green vegetables, 100 grms.—Compote of fruit, 50 grms. *Dinner.*—Meat or vegetable soup, 250 cc. Vegetables, paste or creams, 60 to 80 grms. Stewed fruits or preserves, 50 grms.

D. CHILDREN ABOVE 8 YEARS OLD.—Milk ½ litre or wine and water, 750 cc. Bread at discretion. *In the morning.*—Milk soup or vegetable soup. Café au lait or chocolate (twice a week), 250 cc. *Déjeuner.*—1st. Roast meat, 80 grms. or stew or fish, 100 grms. 2nd. Dry vegetables (or rice or

At the Moabite Hospital, Berlin, there are four degrees of alimentation.

The first and most substantial is that of the inferior staff and convalescents. They have at midday a plate of meat with vegetables, in the evening eggs, herrings, sausages ; in all 40 to 45 grms. of albuminoids corresponding to 200 or 220 grms. of fresh meat. They also receive :—

Rye bread	250 grms.	Butter	50 grms.
Wheat bread . . .	150 „	Beer	330 cc.

In alimentation of the 2nd degree, soups predominate : in the evening only 200 grms. of bread are given, generally wheaten bread ; meat and indigestible vegetables are set aside. The 3rd degree is composed chiefly of meat broths with rice, vermicelli, egg, etc. For the 4th degree, the least substantial, the patient is kept almost entirely on milk and milk soups, the doctor adding in each case what he considers necessary.

The calculated quantities of albumin and ternary matters corresponding to these four degrees are the following : –

	Albumin.	Fats.	Carbo-hydrates.	Alcohol.	Corresponding Calories.
1st degree	83	85	340	10	2,600
2nd degree [1] . . .	70	80	300	—	2,260
3rd degree [1] . . .	—	—	—	—	800
4th degree	—	—	—	—	600

At the Hospital of Halle (Prussian Saxony) the alimentation of sick persons admits likewise of four degrees. The richest provides them with 103 grms. of albuminoids, 96 of fats and 314 of carbohydrates per day. It corresponds to 2,600 Calories.

The average composition of the four kinds of allowances at the Bavarian military hospitals, includes (all calculations made) the following quantities of alimentary principles [1] :—

	1st Ration.	2nd Ration.	3rd Ration.	4th Ration.
Albumin	110 grms.	90 grms.	70 grms.	20 grms.
Fat	42 „	40 „	45 „	19 „
Carbo-hydrates . . .	370 „	340 „	230 „	21 „

paste), 100 grms., or potatoes or seasonable vegetables, 120 grms. Cheese (Gruyère) ; stewed fruit. *Dinner.*—Meat or vegetable soup, 250 cc., 2 eggs or 80 grms. of fish, or 60 grms. of meat. Vegetables as in the morning.

E. Milk Diet. Milk 2 litres.

F. Diet for Ccnvalescent Children.—Regimen B. or regimen C. with the addition of 60 grms. of meat or fowl.

G. Diet of Superfeeding.—Regimen C. or D. with the addition of 100 to 150 grms. of raw meat.—(Extract from the *Annales d'hygiène publique et de médecine légale,* Sept. 1902.)

[1] Not including the optional additions of the doctor.

The highest ration is well conceived, a little weak perhaps for convalescents. It only furnishes young and vigorous men with 2,300 Calories, whilst the adult who has no need to repair the losses of his tissues uses, when at rest, from 2,200 to 2,400 Calories.

It is easy to see that French patients, and particularly patients in the Paris hospitals, are better fed than German patients to-day, especially when, owing to the efforts of the doctors and the Administration, a little more variety and choice of foods is introduced into the hospital regimen.

Alimentation in the Prisons.

It is obvious that the prisoner does not deserve luxury, but only maintenance; still the convict should be placed in normal hygienic conditions and sufficiently fed. From the point of view of justice and humanity, no one would be able to claim the right of adding to the just punishment administered by the law, a fresh punishment arising from an alimentation inadequate to maintain his strength, which under the too often deplorable conditions in which the prisoner is obliged to live, soon cause his health to alter and very quickly make him an invalid expensive to the Administration by reason of the care which would be more than ever necessary to him.

Since we owe the prisoner a sufficient nourishment for maintenance, it will suffice to turn back to the facts given, p. 82, *and seq.*, in order to note that an adult placed in the conditions of a man at relative rest (as is the case of the prisoner if he does not work) requires at least 80 grms. of albuminoids, 40 grms. of fat bodies and 400 grms. of starchy matters. This ration furnishes him with 2,150 theoretical Calories, in reality scarcely 1,950 Calories. If he works, and especially if he is bound down to fatiguing work, the prisoner should be fed like an ordinary workman with a minimum of 135 grms. of albuminoids and 500 to 700 grms. of ternary matters. To force work from a man, even a prisoner, without feeding him sufficiently, is a grave fault from the moral and social, and a grievous error from the economic and physiological standpoint. The prisoner should pay the penalty by loss of liberty, not by that of his health or life, which happens only too often under the irrational system in force, as statistics prove.

As a matter of fact, food of the best quality is never given to prisoners, and their foods are estimated in the raw state; now in these meats, vegetables, bread of the second and even third class, the waste products are considerable; the vegetable food which predominates in prison diet supports the stomach less, as we have seen, and produces less force than animal foods. Besides the diet varies very little; so that for all these reasons,

the quantities of principles mentioned above should be considered far below the real needs.

The administrative regimen of the prisons in France, calculated for the average day, is the following :—

	Quantities in the Fresh State.	Containing:		
		Albumin.	Fats.	Carbo-hydrates.
Bread . . .	820 grms.	68·0 grms.	8·2 grms.	311 grms.
Fresh vegetables	70 „	1·8 „	0·2 „	4 „
Potatoes . . .	110 „	1·8 „	—	20 „
Meat . . .	38 „	7·6 „	2·0 „	—
Rice	19 „	0·5 „	—	7·2 „
Dry vegetables .	60 „	14·1 „	1·2 „	31 „
Onions . . .	10 „	—	—	1 „
Fats	12 „	0 „	11 „	0 „
		93·8 grms.	22·6 grms.	374·2 grms.

This regimen, too poor in meat, would contain the necessary quantity of albuminoids if it were furnished by foods of good quality, if it were more animalized, if it did not offend by the nature of its nitrogenous principles which are nearly all taken from bread, finally if it were not too deficient in fat bodies. It only corresponds *theoretically* to 2,074 Calories, of which hardly 1,750 Calories can be realized, an amount of energy which is not sufficient for the man who does not work, and *à fortiori* if he has to work. Indeed, the theoretic calculation of these Calories should be reduced by at least one-fifth if account is taken of the coefficients of digestibility of the herbaceous foods (of which prisoners' diet is chiefly composed) in comparison with the foods of animal origin as well as of the waste which is considerable for a diet which is chiefly vegetable and of second quality.

In England, military prisoners condemned to more than two months, receive per day 283 grms. of oatmeal, 340 grms. of rice, 226 grms. of bread, 678 grms. of milk. If they are doing fatiguing work, they have three times a week 266 grms. of oatmeal, 900 grms. of potatoes, 226 grms. of meat, 450 grms. of milk and 220 cc. of beer. These regimens are all far better understood than ours.

In Prussia, in prisons under the jurisdiction of the Minister of Justice, prisoners are given on an average per day : 650 grms. of bread, 43 grms. of meat, 25 grms. of fat. This is an altogether insufficient regimen.

In the Belgian prisons, the prisoners dispose on an average per day of 625 grms. of bread, 12 grms. of fat and 57 grms.

of meat. They receive besides, in the morning, café au lait with chicory ; at midday and in the evening a pap of potatoes, vegetables and meat, four times a week. This last is included here per average day.

Usually these unfortunate people, weak, dyspeptic and anæmic, whose nourishment is unvarying in its monotony, end by loathing their food and by enduring hunger rather than partake of dishes which are repulsive to them. It would be logical, it would be humane and in conformity with interest properly understood, to make a little variety in their alimentation were it only that it might be better utilized by them. Vegetables, cheese, wine, beer, cheap condiments (salt, pepper and mustard) should take a place in their menu. This would result in less hospital expenses, and so many complaints the less against a regimen which seems contrived to ruin the health of even the strongest.

Well baked bread of good quality, dry vegetables seasoned with salt, pepper and fat ; a little supplementary meat, common but very nourishing herbaceous vegetables such as cabbage, potatoes, carrots, turnips ; cheese, (a pâte cuite), salt fish (cod, herrings), milk, etc., added to the food of prisoners and in the small proportions that we have mentioned, would allow of introducing into their regimen a little of the variety which preserves the appetite, of giving them more strength to work with, more resistance in the shape of health, whilst reducing their inner feelings of revolt and their ill-will as well as the expenses of supervision and those of the hospital.

It is sad to state that these desiderata have already been frequently named by prison doctors, by the estimable persons who interest themselves in the moral and material lot of these unhappy creatures, by the Press and the Administration itself.

From the point of view of hygiene, of the good keeping of the prisons, remarkable progress has been made. A deaf ear has been turned to all demands which concern alimentation. Supplementary expense is feared. It is also thought, perhaps, better to conquer the often difficult character of the prisoner by a lowering nourishment. However, one cannot allow these unhappy convicts to die because they have not the chance of complaining !

XLIX

ALIMENTATION BY ARTIFICIAL METHODS—BY THE STOMACH TUBE—NUTRITIVE INJECTIONS–ALIMENTARY HYPODERMIC INJECTIONS, ETC.

THERE are cases where a man cannot or will not feed himself in the ordinary way, whether from ulceration, stricture of the œsophagus or of the vocal cords, as in laryngeal tuberculosis for example ; or because hæmorrhage or gastric ulcer is threatened ; or because the patient suffers from vomiting which cannot be checked, or because he absolutely refuses to be fed, as some madmen do ; or because he no longer knows how to eat or can no longer swallow ; or finally because the patient has undergone one of the intestinal operations which demand absolute rest of the alimentary canal.

According to the case, the patient must then be fed by the œsophageal tube or by a stomachic fistula, or by the rectum, by the method of hypodermic injections, or by direct injection of certain nutritive substances into the blood.

Alimentation by the Feeding Tube.—Its use is indicated amongst mad people who refuse all nourishment ; among invalids stricken by paralysis of the muscles which control deglutition ; finally in certain affections of the tongue, of the pharynx or of the oesophagus which render deglutition very painful or impossible.

In these cases, a soft tube is used and introduced by the mouth, or by the nasal passages, when it is impossible to do otherwise. Foods are, by means of this instrument, poured directly into the stomach which has generally twice in the twenty-four hours previously been washed out. Yolk of egg may be thus introduced, milk, clear paps, broth, meat juice, solutions of peptons, egg and milk, fatty emulsions, sweetened syrups, wine and beer in small quantity.

The stomach easily supports 500 to 600 cc. at first, then a litre of these nutritive liquids.

When there is ulceration of the larynx or of the throat, very marked spasm or stricture of the œsophagus, it is necessary to introduce the tube with great caution, and if needed to slightly cocaine the painful parts beforehand. Generally, with these patients, rest in bed is necessary.

Insalivation of the matters thus introduced, even when they are rich in starch, seems superfluous.

Alimentation by Stomachic Fistula.—It finds its use among individuals who, in consequence of wounds with cicatrization of the œsophagus, are absolutely incapable of receiving food by the mouth even by means of the œsophageal probe.

The use of the stomachic fistula is more delicate if it is a question of cancer of the œsophagus and of the cardiac portion of the stomach.

The feeding is effected by the same substances as in the preceding case.

Alimentation by the Rectum.—In cases where it is necessary to spare the stomach, whether because this organ absolutely refuses all nourishment, or because it is impossible to cause food to reach it, or because there is gastric hæmorrhage, ulcer, etc., and it is necessary to leave this organ entirely at rest, food must be given by the rectum. But this mode of feeding cannot be indefinitely prolonged. Nevertheless I have been able, in a case of ulceration of the stomach of a gouty person, to feed him for twenty-two days by the rectum. The patient maintained his strength and his stoutness the whole time. Invalids treated thus have been said to remain in good condition for two months or more.

Clinical observation shows then that patients can be nourished by this indirect means.

The analyses of Ewald made on subjects in nitrogenous equilibrium, have shown that it is possible, by means of nutritive well combined injections, to preserve this equilibrium for some weeks, and that it is possible to feed quite sufficiently in this way while giving the stomach complete repose.[1] Before Ewald, Voit and Bauer [2] had established the fact that peptons, juices of meat, and alkaline albuminates are absorbed by the walls of the rectum, and the cooked fecula is itself transformed into sugar which is afterwards reabsorbed. Propeptons, casein of milk, globulins, the albumin of egg when it is slightly salted or mixed with pepsin (Catillon), disappear fairly quickly[3]; but albuminous matters peptonized by pancreatine, especially when they are well prepared and without bitterness, are preferable. Kohlenberger has shown that even undigested soluble albumins are directly absorbed by the walls of the rectum. Boas has made a similar demonstration for carbo-hydrates when they have been cooked and diluted in water.

In its turn, the absorption of fatty emulsions in man and animals has been established by Czerny and Latschenberger and by Eichhorst. I have observed that wine (Bordeaux, port) is very rapidly absorbed by the rectal walls.

[1] Ewald, *Zeitsch. f. klin., Med.*, Bd. XII.
[2] *Zeitschr. f. Biolog.*, Bd. V.
[3] Arnim Huler, *Deutsch. Arch. f. klin. Med.*, Bd. LXVII.

One should, about an hour before the nutritive injection, give the patient an ordinary one, for purposes of cleanliness, with 8 grms. of salt per litre, so as to empty the rectum.

In order to take care that the nutritive solution enters, it is desirable to employ a long soft tube which is able to pass very high into the large intestine. Four or five nutritive injections may be given in the day once every three hours. Their volume may be 200 to 300 cc. according to the power of endurance of the rectum which in the end supports them very well, especially if some drops of laudanum are added at the commencement of the treatment. With the injections for purposes of cleanliness, which in themselves help to cause the water to be absorbed by the intestinal walls, it can be seen that an invalid may absorb even up to 2 litres of liquid daily.

We may employ as a fundamental nutritive liquid, a solution of a tenth to a fifteenth of pancreatic or pepsic peptons. We may also make an emulsion with the yolk of two eggs, or if necessary two whole eggs,[2] to which is added little by little, blending it by whipping, a solution of glucose and cane sugar in 8 parts of water,[3] a spoonful of flour, a spoonful of wine and 2 grms. of salt, the whole at 36°. If required a little tepid, milk may replace the glucose and the flour. I think that oily emulsions (facilitated by the addition of yolk of egg) are not so well absorbed as the starch of flour which plays the same rôle.

Maragliano has given the following formula for nutritive injections :—

Muscles of beef pulped by scraping with a knife . .	300 grms.
Fresh ox pancreas minced	150 „
After having mixed, add:	
Ox gall	25 grms.
A litre of water containing: bicarbonate of soda . .	5 „

It should be left for two hours at the temperature of the room and injected in four or five times.

Milk mixed with 1·50 grms. of bicarbonate of soda per litre is very well borne by the intestine, but in this case, above all, it is necessary that the cleansing injection which precedes, should be very scrupulously administered and even made antiseptic (0·3 grm. of benzonaphtol) otherwise the colibacillus would coagulate the casein which would no longer be absorbed save with difficulty.

[1] Whipped and peptonized eggs (in presence of 1·5 milligrms. of HCl), or better *pancreatinized*, are absorbed more easily than eggs simply emulsioned (Catillon, Huber). If the white of the egg is not tolerated, only the yolks of three or four, which are carefully emulsioned, may be used.

[2] Very concentrated glucose irritates the rectum and afterwards makes alimentation more difficult. It is better to replace a little sugar by the flour of wheat or rice or by a little dextrin.

The patient who is fed by means of injections ought to remain quietly in bed and well covered up, to avoid as much as possible rectal intolerance and the alimentary needs which are increased by the losses of heat and the reflexes due to cold. The liquid substances injected ought to have a temperature of 37° to 38°.

Among stout women suffering from stomachic intolerance, two injections a day, each of 600 grms. of water and 4 grms. of salt, or 400 grms. of water and 200 grms. of soup given at 38° after a cleansing injection, allow of the preservation of strength for a long time and often of the calming of the stomach, which may then support dishes of easy digestion, such as raw meat or grated ham swallowed without chewing.

Nutritive injections well composed and well administered allow of invalids being fed for a long time by the rectum; but they must not be depended on too much if it is a case of children, nervous people, or those with whom a tumour or a stricture of the œsophagus prevents all natural alimentation.

Alimentation by subcutaneous Injections.—It seemed natural to try to feed invalids by hypodermic injections; but that method is far from having maintained what it appeared to promise. It was known to be impossible to get albuminoid matters absorbed with any utility in this way. Either the matters thus introduced provoke local troubles, indurations, abscesses, or they are only very partially absorbed; or, after having penetrated into the blood, they pass just as they are, into the urine. Albumin, different peptons, alkaline albuminates, propeptons, etc.—nothing has succeeded. Thus we only succeed in considerably irritating the kidneys and provoking albuminuria.

We have already seen that before feeding the tissues, the albuminoids must pass, by traversing the alimentary canal and the lymphatic ganglions of the intestine, through a series of transformations and decompositions which allow of their final assimilation. It is these divisions which, in the case of hypodermic injections, are lacking in the albuminous matter injected under the skin, and this indispensable condition is sufficient to hinder the utilization of the greater number of alimentary principles.

Glucose in solution to 60 or 80 grms. per litre, with the addition of 5 to 6 grms. of salt, is well absorbed by the subcutaneous method. But we cannot thus inject sufficient quantities.

Subcutaneous injections of fats or of olive oil repeated two or three times a day, at the rate of 20 to 30 grms. each time, are well utilized by the system (Leube). The injections should be given slowly. Fatty bodies may even be used as vehicles or medicinal products, of creosote for example (Burlureaux), but we cannot feed very effectively thus. The fatty bodies to be injected should have been previously sterilized.

Alimentation by intra-venal Injections.—In very serious cases one is sometimes tempted to sustain the invalid by intra-venal injections either with defibrinated blood, or with natural serum, or with artificial serum. Blood may be injected from vein to vein, but it should be taken from an animal of the same kind, which renders this method amongst men almost inapplicable. Natural serum should be sterilized ; it is not without its inconveniences, nor even without danger. Artificial serum is better. It is prepared by dissolving 7 grms. of salt, 1 grm. of phosphate of soda and 0·5 grm. of phosphate of potash per litre of water, raising to boiling point. We may also content ourselves with dissolving 8 grms. of salt in a litre of water which is afterwards sterilized by boiling, and left to cool sheltered from the dust of the air.

The injection by the subcutaneous method of this artificial serum to the amount of 500 to 1,000 cc. and more in the twenty-four hours, constitutes one of the most powerful means which the medical man has within reach for rapidly repairing the strength of invalids and bringing back normal functional activity.

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METHODS ENABLING US TO EXAMINE THE EFFECTS ON THE SYSTEM OF ALIMENTARY REGIMENS AND MEDICAL AGENTS

THE individual, whether in good health or ailing, who undergoes such or such a mode of alimentation or treatment, is influenced by it for good or evil, and it is of much importance to be able to follow, so to say, day by day the effects of the regimen or medical treatment which has been instituted.

Method of Clinical Observation.—To this end the medical man can have recourse to a purely clinical examination of the invalid, a method which consists in taking account of the characteristic signs of the state of different functions, the appetite, digestion, excretions, pulse, rhythm of the heart, vascular tension, temperature, respiration, variations of sensation, muscular power, the general aspect of the patient, etc.

Although full of interest and providing the most valuable indications, this method of observation, the old clinical medical method, gives above all general impressions, sometimes also precise indications, but indications which do not always give an exact, detailed and daily appreciation of the progress of the invalid or of his return to health, still less of the losses or gains made by each of the principal organs or tissues. The clinical method is only able to indicate in a general way the sense in which such or such part of any regimen should be modified.

Nevertheless, everything which can be measured exactly can be translated into curves, the component parts of which one can deduce and the significance of which is one of the most important in medicine. It is thus that the state of the forces gauged by the dynamometer, the number of the beats of the heart and pulse, the rhythm of the respiratory movements, the degree of arterial tension, that of the temperature, the counting of the red or white corpuscles of the blood, the volume or colour of the urine, all these data are valuable for estimating the effect of a regimen, or even of a medical agent, because together, sometimes even separately, they bring clear and definite indications. The continued lowering of the temperature in the case of a feverish, typhoid or tuberculous patient, etc., if it is produced apart from any other intervention than the change of regimen, shows the good effects of it;

the elevation or arrest in the increase of the number of the red corpuscles of the blood in anæmia or convalescence according as he has recourse to such or such remedy or alimentation, may be sufficient to guide the medical man in the choice of his therapeutic or nutritive agents.

There is another sign which also gives precise indications of the value of the alimentary regimen adopted—the variation in the weight of the subject. The weighing of invalids is adopted, we think, far too rarely. It is scarcely practised, save in tuberculous cases or in chronic ailments. It would, however, be easy to weigh ordinary invalids, placed in an old armchair on the Roberval balance which can give the weight of a man to almost 30 or 40 grms. This weight taken each day, or alternate days, would give us a serious check over the effects of the regimen followed, the efficacy of such or such a course of treatment, and the general state of the patient. Nevertheless, weight itself, like the other general signs, only gives us a summary indication; it does not indicate which organ may have gained or lost in substance, nor what tissues or what kind of principles—nitrogenous, fatty, etc. —have accumulated in the organs or have disappeared. Besides, fairly important modifications may come without weight giving any clue to them; for example, a loss of muscular tissue compensated by an almost equal gain of fats or water.

Formerly the medical man concerned himself with the appearance of the urine and excretory matters; he knew how to draw from these more or less precise conclusions as regards regimen and treatment. This examination can indeed furnish some summary information on the digestibility or indigestibility of such or such alimentary matter, or relatively to its influence on the urinary secretion, but to-day it is no longer by simply taking into account the superficial aspect of the excretions, but rather by examining their total composition, taking their volume and weight and comparing them with the normal composition, weight, etc.; it is above all by striking the detailed and complete balance of the whole of the excretions and of the aliments introduced, that the modern biological chemist and physiologist are able to follow day by day, and almost organ by organ, the effect of a method of treatment or of a regimen.

We are now able not only to determine exactly the influence which such and such a regimen has on the general health, but to mark the effects in detail and following the feeding adopted, to state precisely the daily gain or loss of the system in muscular matter, in fats, in water, in salts, etc.

To obtain these precise indications, different methods are employed which we shall now explain.

Method Founded on the Complete Determination of the Nutritive Balance.—The method which enables us to establish, at any

moment, the state of nutrition by the complete nutritive balance corresponding to a fixed regimen, is based on the following considerations :

It has been established first, in particular by the experiments of J. B. Boussingault, then of V. Regnault and Reiset, and later of Bidder and Schmidt and of Voit, etc., that almost the whole of the alimentary nitrogen is found again in the urine, fæcal matters and the products of desquamation. Further, the loss by the epidermis and hair only represents daily in man 0·3 grm. to 0·4 grms. of nitrogen out of 16 to 18 grms. of total nitrogen eliminated. As to the exhalation of nitrogen, whether in a natural state or in the state of volatile nitrogenous products, more or less complex by the skin and the lungs, it is almost nil, as the preceding authors, and later Ranke, Pettenkoffer and Voit, etc., have established.[1]

If then the quantity of nitrogen which exists in the total sum of the foods of a subject experimented on is determined, and if, on the other hand, by collecting the whole of his excretions, the total nitrogen is measured, the difference in excess or deficit will give the nitrogen retained or lost by his tissues during the period which we are considering. But as a very large part of this nitrogen exists in animals and man in the state of albuminoid principles, and as these substances contain on an average 16 per cent. of this element, it follows that for each gramme of nitrogen vanished from the total of the excretions compared with that which the foods have introduced in the same time, the system has benefited by $\frac{100}{16}$ grms. or 6·25 grms. of albumin ; and on the other hand, it will have lost this quantity by each gramme of nitrogen present in the excretions above that which the foods have introduced in the same time.

Reckoning that the muscles form by far the most important albuminoid tissue in the animal, it is possible, as Voit did, to calculate the nitrogen gained or lost no longer in dry albumin, but in fresh muscular flesh. Now, as this contains for 100 parts 3·35 of nitrogen on an average, it will suffice to multiply the figure representing the loss or gain of nitrogen observed in an animal or a patient under experiment by the coefficient 29·9 (or 30 in round numbers), to obtain relatively to the period of time which we are considering, the gain or loss in muscular flesh of the subject under observation.

As to the quantity of alimentary albumin absorbed, it is equal to the weight of total nitrogen of the foods, minus that which is found again in the intestinal excrements, the difference being multiplied by the coefficient 6·25 above. Generally for 18 grms. of alimentary nitrogen, the excrements contain daily 1·4 grms.

[1] A man eliminates, it is true, per day 4·5 to 5 litres of nitrogen by the skin and the lungs, but the nitrogen is partly of atmospheric origin and not alimentary.

of nitrogen. But it must be understood that this relation may be very variable according to the method of alimentation and the state of health of the individuals.

The carbon of the organism being eliminated in the state of carbonic acid by the lungs and skin, and under the form of very varied organic matters by the urine and fæcal matters, if by the methods of Reiset, Pettenkoffer and Voit, of Richet and Hanriot, of Atwater, etc., the quantity of carbonic acid CO^2 expired or perspired is determined in grammes, and if this quantity is multiplied by 0·273 (the coefficient of proportional change in weight from CO^2 into corresponding C) we shall get the carbon lost by the lungs and skin in the space of time during which the subject has been under observation. If to this carbon be added that which has been excreted during the period by the urine and fæces (it is known by an elementary analysis of the urinary residue and of the fæcal matters) the total of the carbon lost in the course of the observation will be obtained. By deducting this weight from that of the carbon furnished by the foods, we shall have as the difference, the weight of the *total carbon* fixed or lost by the patient during this period. On the other hand if, as we stated above, the nitrogen lost or gained by the subject in the same time has been measured, it will be easy to infer from it the carbon assimilated in the state of proteid substances, because nearly the whole of the fixed nitrogen is under this latter form, and we know that these substances contain for 16 grms. of nitrogen, 54 grms. of carbon. If then we multiply the gain or loss of nitrogen by $\frac{54}{16}$, that is to say by the coefficient 3·4, we get *the carbon fixed under the form of albuminoids*. Thus calculated, this carbon subtracted from the loss or gain of *total carbon*, will give as the difference that which has been lost or gained under any other form than that of proteid bodies. Let us suppose for the sake of clearness that we may represent this weight of *non-albuminoid carbon* by p.

Let us observe now that the animal only stores appreciably in his tissues as organic materials, muscle or fat (glycogen and other ternary substances only existing in it in very small proportions). We may then say that the excess of carbon p, that is to say that which does not correspond to the albuminoid matters gained or lost in the time considered, is the carbon which corresponds to the fats ; to those which are formed if this weight p is positive, or destroyed if it is negative. And as these fats contain on an average 76·5 per cent. of carbon, it follows that we shall have the weight P of the assimilated or dissimilated fats by multiplying p by $\frac{100}{76{\cdot}5}$ or by the coefficient 1·310.

In order to apply what has just been said, let us take some examples : First the case where the nitrogen of the foods for twenty-four hours exceeded, for example, the nitrogen excreted by 3 grms. per day, and where, in the same time the carbon expired or

rejected by the excretions of every kind was less by 22 grms. than the alimentary carbon. The system has then stored up in this time 3 grms. × 6·25 = 18·75 grms. of albuminoid matters. The carbon which corresponds to these 18·75 grms. of these matters is equal to 3 grms. × 3·4 = 10·2 grms. There has then been in this same time 22 grms. – 10·2 grms. = 11·8 grms. of carbon fixed by the system under the form of fats, which corresponds to 11·8 grms. × 1·31 = 15·45 grms. of fat bodies. We shall conclude then that during the period considered, there was : *gain in albuminoids* = 18·75 grms ; or calculated in muscular tissue, 3 grms. × 29·9 = 89·70 grms. Simultaneously, the gain in fats was 15·45 grms.

There may, on the contrary, be the very different case, where an excess of 3 grms. of nitrogen is found in the excretions of the subject under observation in comparison with the nitrogen of the daily total of foods, and let us suppose also that there have been 22 grms. of carbon less in the excretions than in the whole of the foods consumed. In this second case 3 grms. × 6·25 = 18·75 grms. of albuminoid matters have been lost, but which contained 10·2 grms. of carbon. These 10·2 grms. of carbon have disappeared from the system with the albuminoids ; and in order that the system may have benefited by a gain of 22 grms. of carbon it is necessary that it should have made up the deficit of carbon, corresponding to the albuminoids lost, that is 10·2 grms. and still gained 22 grms. in addition ; in a word, it is necessary that it should have established, in the state of fats, the carbon corresponding to 22 grms. + 10·2 grms. = 30·2 grms. This number multiplied by 1·31 gives 39·56 grms. which consequently corresponds to the weight of fatty bodies gained by the system during this period when the subject lost nevertheless 18·75 grms. of albuminoids.

It is thus that the abstract or exact balance of the alimentary nitrogen and carbon, compared with the total weight of the same elements found in the liquid or gaseous excretions of the subject, allows us to calculate, as we see, the quantity of albuminoids or (in multiplying this weight by about 5) the weight of muscular tissue and the quantity of fat gained or lost in a given time by the subject under observation.

As to the balance of water gained or lost by the tissues, it is inferred from the difference between the water introduced by drinks and foods and that which is contained in the whole of the excretions including perspiration and cutaneous and pulmonary expiration.

The balance of the mineral matters is established in manner quite similar according to the difference between the quantity of it which is introduced by the whole of the foods and that which is excreted by the different channels.

Suppose now that we wish, for example, to test the influence

which such determined alimentary or medicinal matter may exercise on the nitrogen and carbon changes, for example on the assimilation of albuminoids; we shall begin by putting the organism into a state of nitrogenous equilibrium, that is to say we shall, by successive attempts, reach the point of giving the patient under observation a quantity of nitrogenous and ternary foods of known composition and weight, so that every twenty-four hours the losses and gains of the system in nitrogen balance almost exactly. After having established the exact nutritive balance, not allowing from that time more than a small loss or gain of nitrogen and carbon corresponding to the mode of alimentation and thus determined, if it is a question of the study of a nitrogenous alimentary matter, for example, a certain proportion of the nitrogenous foods of the preceding equilibrium allowance will be replaced by a quantity of the nitrogenous matter which we wish to study, a quantity containing the same weight of nitrogen as that which is withdrawn, and the loss or gain of nitrogen corresponding to this period, will be determined. This loss or gain will allow us to compare the utilization of the new matter with that of the matter it replaces. On the other hand, if we wish to determine what is the influence which a ternary matter, a sugar or fat for example, exercises on the assimilation of nitrogen compared with the action of another ternary substance, this sugar or this fat must be added to the allowance, or better, it may be substituted for an equivalent weight of sugar or fat to be compared, and the changes of nitrogen which will be effected under the influence of the new alimentation will be determined, care being certainly taken only to determine the rate of the changes after a period of three days of the new regimen has passed, since the state of the previous nutrition influences the manner of dissimilation almost during this period of time (Moreigne). From the rate of the fresh nitrogenous changes we shall conclude what is the relative influence of the fats or sugars thus introduced on the assimilation or dissimilation of the proteid bodies of the ration under study.

If we wish to study no longer the comparative influence of the substances, but the action of one and the same substance according to its weight, in a subject in nitrogenous equilibrium, we must add to a constant allowance of foods an increasing or decreasing weight of the substance under study, and the influence on the assimilation of the nitrogenous principles of these successively increasing or decreasing quantities of additional ternary matter will be established by the balance of losses or gains of nitrogen.

In the same way, the study of the fattening or loss of fats of the subject may be made, according as such or such foods take their place in his diet, the substances or agents the influence of which we wish to estimate being for the rest nitrogenous or not, ali-

mentary or medicinal, or even consisting of simple physical agents such as repose, exercise, cold, hydrotherapy, etc.

Method based on the Determination of the Respiratory Coefficient.—The extent of the nutritive changes, and up to a certain point their nature, may be determined by consideration of the quantities of oxygen consumed and carbonic acid exhaled by the lungs. These quantities depend, it is true, on the nature of the alimentation, but this varies little for each individual with a determined mixed alimentation, and whether the external conditions of work, repose, temperature and health happen to change, or whether, under well defined conditions, the mode of alimentation is made to vary, the extent of the pulmonary changes and their nature will give fairly precise indications on the phenomena of metabolism which are taking place in the organs of the subject whose nutrition is being studied or of the patient under treatment.

From the point of view of technique, many methods have been proposed for measuring the respiratory changes. Generally an apparatus with valves [1] and meter for the purpose of measuring the quantities of air inhaled and exhaled, and of making as many times as one wishes, in the course of the experiment, successive collections of the air which comes out of the lungs and which is then submitted to analysis, allows of the calculation of the quantity of air inhaled, of the composition of the gases exhaled, of carbonic acid (CO^2) which is produced and of the oxygen (O) which has disappeared at the same time. The coefficient $\frac{CO^2}{O^2}$ (expressed in volumes) is called the *respiratory coefficient.* We know that it varies in the normal state from 0·80 to 0·88 ; it is on an average 0·84. A healthy man of average weight and at repose, breathing freely, takes from the surrounding air from 530 to 560 litres of oxygen per twenty-four hours and exhales 450 to 470 litres of carbonic acid.

The respiratory coefficient $\frac{CO^2}{O^2}$ increases during work as well as the absolute quantities of CO^2 and of O^2 produced or consumed.

After having established what is, for an invalid or healthy person at rest, the value of his respiratory quotient and the absolute quantities of CO^2 and of O^2 expired and consumed by him, it is possible, by introducing into his diet such or such foods, to determine their influence on the value of his respiratory coefficient, and on the quantities of carbonic acid formed and oxygen absorbed in the twenty-four hours, for example. When

[1] Water or mica valves may be constructed which cause the disappearance of almost all friction and pressure (*Dr. Bidet*).

the dissimilation produced in the midst of the tissues bears especially upon the sugar or on the starchy matters, the respiratory quotient may equal and even exceed unity (Hanriot). It falls to 0·72 or 0·73 with a purely flesh diet and to 0·70 when the fats become more particularly dissimilated.

The absolute and relative amounts of carbonic acid produced and oxygen absorbed are very variable from one individual to another. But, under average conditions, and especially in a state of repose and of emptiness of the intestines, these numbers vary very little for the same person. When his respiratory constants have been determined under these conditions, it will then be possible to examine the influence that the absorption of such or such an alimentary principle may have on these data.

A similar study may be made by the same method if it is a question of determining the influence of such or such a medicine on the pulmonary changes.

Method of Urinary Coefficient.—There is another method of studying the effects of different diets as well as of medical treatment, founded on the determination of the *urinary coefficients.* This method consists in measuring the principal elements of the urine and by drawing from their values and particularly from their ratios by weight, the indication of the mode in which the system is acting. In this way we do not measure, as we can by the preceding methods, the absolute extent of the nutritive phenomena, but the quality so to speak of the organic discharge of functions.

The examination of the urinary coefficients may also allow of determining sometimes the nature of the changes and even the organs which are their seat.

But before explaining the signification of these urinary coefficients and their utilization, I think it useful to call to mind again that when passing from one diet (the constants of which have been determined) to a new diet, it is only three days at least after the substitution of the latter for the old, that the new state of functional equilibrium can be considered as attained. Then only is it permissible to compare the data thus obtained with the preceding data.

The most useful ratios to know between the weight of the principles excreted daily by the kidneys are the following :—

The ratio between the nitrogen excreted under the form of urea and the total nitrogen of the urine or nitrogenous coefficient ;

The ratio of the urinary carbon to the total nitrogen ;

The ratio of the phosphoric acid to the total nitrogen ;

The ratio of the weight of urea to that of total fixed matters ;

The ratio of uric acid to urea ;

The ratio of the mineral matters of the urine to the total fixed matters.

a. The *nitrogenous coefficient* $\frac{\textit{nitrogen of the urea}}{\textit{total nitrogen}}$, which is also called *coefficient of nitrogenous utilization*, measures *the utilization of the assimilable* nitrogenous products. It is admitted that it attains its maximum when all the nitrogen which can be transformed into urea in the system has passed under this last form. This ratio in the normal state is equal to 0·87; it never exceeds 0·92 or 0·93 in a healthy man; that is to say that for 100 parts of nitrogen arising from the dissimilation of the tissues, or received by the foods and eliminated by the kidneys, 87 (or 93 at the most) are found again in the urine under the form of urea.

In the same subject this nitrogenous relation may vary from one day to another, but the nature of the food influences it very little. However, if the quantity of foods taken exceeds the normal limits, the system has not the time to utilize them, and as the urea produced diminishes relatively to the total alimentary nitrogen, this ratio falls below 0·80 and even 0·79. It becomes lower also in all illnesses in which the intraorganic oxidations decrease: anæmia, rheumatism, neurasthenia, hysteria, leucæmia, pneumonia, tabes, etc. Water and all aqueous drinks, especially alkaline drinks, raise the nitrogenous ratio. It rises with meat diet and decreases with vegetarian diet.

On the other hand, the nitrogenous matters *which have escaped oxidation* can be revealed and measured by the variations of the quantities by weight that the phosphomolybdic, phosphotungstic or silicotungstic acids precipitate in urine previously acidified by hydrochloric acid. The phosphomolybdic reagent which precipitates these nitrogenous compounds and which can be utilized at the sick-bed, is obtained in the following way:—

Phosphomolybdic acid	1 grm.
Hydrochloric acid	20 ,,
Water	150 ,,

15 cc. of this reagent are added to 25 cc. of urine as a test. To obtain an exact determination, the precipitate which forms should be washed with hydrochloric acid diluted with its own volume of water, dried and weighed.

This reagent brings with it in particular all the urinary alkaloids.

b. The ratio $\frac{\textit{urea}}{\textit{total organic matter}}$ constitutes the real coefficient of *organic utilization*. It measures the relative richness of the organic urinary wastes in urea. It is in the normal state from 89 to 90 per cent. The 10 per cent. of organic matters which do not normally change into urea are:—

Uric acid	for	1·60	in	10
Hippuric acid	„	1·80	„	10
Urinary matters (colouring and extractive) . .	„	6·60	„	10

The proportion varies almost like the preceding.

c. the ratio $\frac{\textit{total carbon}}{\textit{total nitrogen}}$, or *ratio of Ch. Bouchard*, has been especially studied by this savant. He has remarked that in the normal state, the liver is the organ which acts the most efficaciously in oxidizing the carbon in relation with the circulating nitrogen and in turning it, either by hydrolysis towards the intestinal channel, or by oxidizing it towards the pulmonary channel. This ratio appears then to vary inversely with hepatic activity and consequently to give the inverse measure of it. It changes with age: between fifteen and forty years it is 0·76; later it increases, and in old age it rises to 0·91. It is, on an average, between forty and sixty years, equal to 0·87. It decreases if, owing to the carbon taken by the liver happening to increase, the urinary carbon diminishes. Hepatic insufficiency makes this ratio increase as well as exaggerated alimentation.

d. The urinary ratio $\frac{\textit{phosphoric acid}^{1}}{\textit{total nitrogen}}$, or *Zuelzer's ratio*, represents the rule of dephosphoration of the system, that is to say the losses of phosphorus corresponding to a certain state or to a determined weight of phosphoric foods. Each time that phosphorus is fixed in the tissues, this ratio diminishes; it increases in the contrary case. Zuelzer's ratio is about 0·18 in the normal state; and varies very slightly in one and the same healthy individual if the regimen varies little. It increases with milk diet as well as by taking foods rich in phosphorus such as bread, egg, etc. It allows us then to follow the fixation or the dissimilation of phosphorus in invalids or in subjects put on a fixed diet.

e. The ratio $\frac{\textit{uric acid}}{\textit{urea}}$ measures the proportion of nucleinic matters dissimilated compared with the urea formed at the same time. It rises if the food is enriched in compound nitrogenous and phosphoric albuminoids and is proportional to them. In a state of health and under average feeding, it is at least equal to $\frac{1}{40}$ or 0·025, that is to say that, normally, for each grm. of urea thrown off, the urine contains 0·025 grm. of uric acid. This ratio is lowered by the use of chloruretted alkaline waters, aqueous drinks and generally by all food which increases the excretion of urea. It rises if coffee, tea, chocolate and alcohol are used, if an abuse is made of bread, gelatinous or oxalic foods

[1] Expressed in P^2O^5.

and some other substances which increase the excretion of uric acid. It rises each time the patient has digestive, cutaneous or pulmonary troubles.

f. The ratio $\frac{\textit{sulphur of the sulphates}}{\textit{total sulphur}}$, or *Baumann's ratio*, varies in the normal state from 0·80 to 0·90. It represents the coefficient of oxidation of sulphur or that of the albuminoids which bring it, because it is known that the major part of alimentary sulphur comes from proteid principles which contain 1 per cent. of it on an average, and which introduce daily into the system 1 grm. at least of sulphur corresponding to 2·5 grms. and more of SO^3. Baumann's coefficient measures then indirectly the more or less complete oxidation of the albuminoid substances, and ought to, and indeed generally does, follow the oscillations of the nitrogenous coefficient.

g. Finally, the ratio $\frac{\textit{mineral matters}}{\textit{total fixed matters}}$ is called the *coefficient of demineralization*. It has been particularly emphasized by A. Robin. It oscillates in the state of health between 0·30 and 0·32; that is to say, normally, the saline materials of the urine represent in weight 30 to 32 per cent. of the totality of the fixed substances of this excretion. The increase of this coefficient is the indication of an exaggerated loss of mineral salts, that this loss had its origin even in the alimentation which may, in some cases, introduce these saline substances superabundantly, for example in the case of the vegetarian, or that it has been provoked by a state of decay of the system such as tuberculosis, phosphaturia, diabetes, phosphorism, etc. We have seen (p. 509) this urinary coefficient rise to 48·5 per cent. in certain cases of anæmia, with rapid demineralization of the blood and tissues, and go down again to 35·6, that is to say to almost its normal value, after some weeks of a diet of remineralization.

Method based on the Determination of the Average Weight of the Molecule.—The weight of the molecule of the albuminoids of our tissues varies according to its nature from 3,000 to 18,000 and more. The weight of the molecule of urea is 60, that of uric acid 168, that of the hippuric acid 179, etc. In proportion as the albumin of our organs is made to undergo a more complete disintegration, the molecular weights of its successive derivatives diminish, approaching more and more that of urea, the final form of this dissimilation. If, then, it were possible to obtain the *average molecular weight* of urinary molecules, we should have a number so much smaller and nearer to 60 as the dissimilation or vital metabolism had been more perfect.

The cryoscopic methods of Raoult allow us to solve this problem. We know that water freezes at 0°. Now, Raoult has established that if water contains substances in solution, the lowering of the

freezing points of the different solutions are in proportion to the *molecular* concentration, whatever be the nature of the dissolved substances. Equal lowerings indicate then that the liquids contain the same number of molecules. For one gramme molecule per litre of water, this lowering which is, we repeat, the same whatever be the nature of the dissolved substance, is equal to 1·85°. This said, if Δ be the lowering of the freezing point observed for an aqueous solution, we shall have to express the number N of the molecules in solution, $N = \frac{\Delta}{1 \cdot 85}$. Let us suppose that the solution contains, per 100 cubic centimetres, p grms. of the dissolved substance, the lowering of the freezing point, if the solution only contained 1 grm., would be then $\frac{\Delta}{p}$, which is called the specific lowering of the freezing point. For a solution containing the weight M of a molecule expressed in grms. or M grammes for 100 cubic centimetres, the lowering will be $\frac{M\,\Delta}{p} = 1 \cdot 85$, an equation whence we infer the weight M of the molecule in terms of Δ and of p, or $M = \frac{p \times 1 \cdot 85}{\Delta}$.

If it is a case of urine, the average molecular weight of the *elaborated molecule* which we will represent by μ is defined by Ch. Bouchard; *the average weight of the organic molecules of the urine* (deduction being made of the chloride of sodium [1] and if possible of albumin and glucose which would give separately other indications). To obtain μ we determine: 1st, the solid matters of 100 cc. of urine; 2nd, the chloride of sodium of these 100 cc.; 3rd, the freezing point Δ of the urine. From the weight of the solid matters of 100 cc., the weight of the corresponding chloride of sodium is subtracted; the difference gives the weight of elaborated matters.[2]

We multiply by 0·6 (lowering of the freezing point of a solution of salt at $\frac{1}{100}$), the weight found of chloride of sodium (let this product be d), and we deduct from the Δ found, the lowering d thus calculated which corresponds to the chloride of sodium; thus we have $\Delta - d = \delta$ for the lowering of the freezing point relative to the really elaborated matters. The formula $\mu = \frac{p \times 1 \cdot 85}{\delta}$ allows of calculating the average weight of the elaborated urinary molecule.

[1] Considered in this case as representing almost by itself the total influence of mineral salts not elaborated.

[2] The weight of the albumin and sugar would be deducted in the same way if necessary.

Ch. Bouchard has thus found that in general, for the normal state, the average weight of the elaborated urinary molecule is 76, with oscillations varying from 82 to 68.

The average molecular weight rises at the least disorder in health and augments very notably in sick persons.

We see how numerous and precise are the indications which may be drawn from each of these methods of examination of the alimentary regimens in relation to the state of the various organs, and to the precise influence which may be exercised on the discharge of vital functions by the medical treatments or diets which are put into practice.

THE END

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Butler & Tanner, The Selwood Printing Works, Frome, and London.